British Telecommunications Engineering

VOL 8 PART 2 JULY 1989

The Journal of
The Institution of British Telecommunications Engineers

Published in April, July, October and January by *British Telecommunications Engineering Journal*, 2–12 Gresham Street, London, EC2V 7AG. (Formerly *The Post Office Electrical Engineers' Journal* Vols. 1–74: April 1908–January 1982.)

Printed in Great Britain by Unwin Brothers Limited, The Gresham Press, Old Woking, Surrey GU22 9LH.

Subscriptions and Back Numbers
Price: £1·50 (£2·00 including postage for UK; £2·50 including postage for overseas). Annual subscription (including postage and packaging): £8·00 (UK); £10·00 (overseas). Overseas customers can pay by sterling drafts drawn on London for £10·00. Payment by cheque drawn in US dollars will be accepted at the price of $22·00 to cover bank charges.

Price to British Telecom and British Post Office staff: 90p per copy.

Back numbers can be supplied if available, price £1·50 (£2·00 including postage for UK; £2·50 including postage for overseas).

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0262-401X/89 $2·00 + ·00

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VOL 8 PART 2 JULY 1989

ISSN 0262-401X

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EDITORIAL

Striking the balance between detailed knowledge and an awareness of the systems and techniques used in telecommunications is a continuing problem, not only for the professional engineer and the technician in the field, but also for their sources of information. Within the Institution of British Telecommunications Engineers, lectures and visits are a means by which information is disseminated, and are particularly effective especially when a lively interactive debate follows. But lectures are not as fully supported as they might be. In contrast, the *Journal* reaches a far greater number of people, but does not have the advantage of instantaneous feedback, and herein lies a major problem—how do we gauge that the content of the *Journal* is right for its readers? In the past, the *Journal* has tried to steer a sensible course through the conflicting needs of the technician on the one hand and the development engineer on the other. The detail that the senior manager might find uninteresting may be a shining light to other grades. Similarly, the 'Its too technical for me' syndrome is dangerous—the information is there because that is what is happening today; it will be commonplace tomorrow. The Council of the Institution and the Board of Editors of the *Journal* are spending considerable time and effort in reviewing how best the Institution and the *Journal* can serve their members, but in the end it is you yourselves who must make the effort to make maximum use of the opportunities provided.

Electromagnetic Compatibility and the 1992 Single European Market

R. D. MARTIN-ROYLE†

As part of the move towards a Single European Market by end-1992, the European Community is proposing to adopt a Directive on the Electromagnetic Compatibility (EMC) of devices, equipment and systems. This article, the first of a series, reviews the key points of the draft EMC Directive, and considers its mode of application in the UK and the likely implications for BT purchasing and provisioning activities.

INTRODUCTION

Electromagnetic compatibility (EMC)—the ability of a device, piece of equipment or a whole system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything else in that environment—is a subject which has long exercised the design skills of telecommunications engineers. So why the current intense activity on the topic?

Clearly there has been and continues to be explosive growth in the use and deployment of complex and advanced equipment in telecomms operational buildings, the home and in particular the office. The advance in computing and information technology has, in a relatively few short years transformed the office and workplace environment. Very few locations now lack either a personal computer, a video display unit (VDU), a data terminal, facsimile machine (fax), an advanced PABX and telephone terminal equipment or similar device. To ensure satisfactory operation of many co-located equipments, special attention must be paid in their design to avoid creating interference, while at the same time they themselves must be sufficiently immune to interfering signals to ensure satisfactory operation.

These requirements present stringent design problems, particularly in the way in which the equipment is connected by cable to the outside world. Significantly, the use of digital as opposed to analogue signal processing has increased the challenge.

So there is a very real and growing technical problem to be addressed.

At the same time there is a new legislative situation due to the objective of a Single European Market by the end of 1992.

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THE 1992 SINGLE EUROPEAN MARKET

The objective of creating a single common market in the European Community (EC) goes back to the Treaty of Rome which established the Community over 30 years ago. Despite the elimination of tariff and quota restrictions between member States, the common market envisaged in the Treaty is not yet a reality. The free movement of goods, for example, is impeded by technical barriers; growth of a free and competitive market for services is blocked by a range of national restrictions; and the efficient operation of the market as a whole can be obstructed by national public purchasing and subsidy policies which distort competition. Therefore, by means of the Single European Act in 1985, the Community Heads of Government committed themselves to achieving the Single European Market progressively by 31 December 1992.

The Single European Market is defined as 'an area without internal frontiers in which the free movement of goods, persons, services and capital is ensured in accordance with the Treaty of Rome'.

Among the main priorities identified by the Heads of Government was the elimination of technical barriers to trade. Although work had been carried out on this topic before 1985, progress was slow and the results disappointing.

To eliminate technical barriers, the EC issues a Directive which usually requires each Member State to introduce legislation to enact that Directive. In the past, getting agreement to a Directive was slow, but two factors have been introduced which are speeding up the issue of a Directive. First, agreement is by weighted majority rather than by unanimity as in the past; secondly, the technical requirements are by reference to relevant (European) standards.

Flow diagrams of the new co-operative procedure are given in Figures 1 and 2. Initially, the Commission makes a proposal for a Direc-

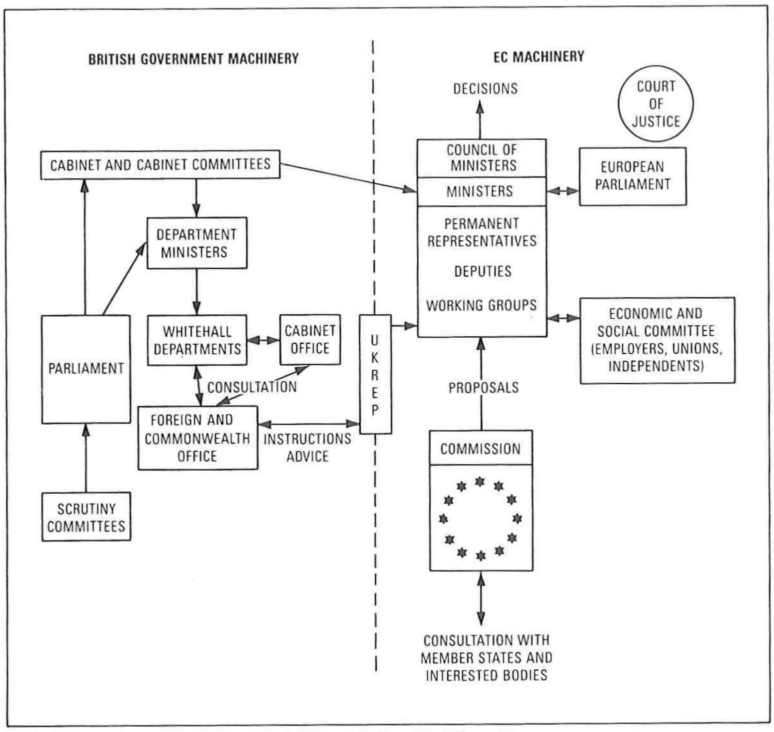
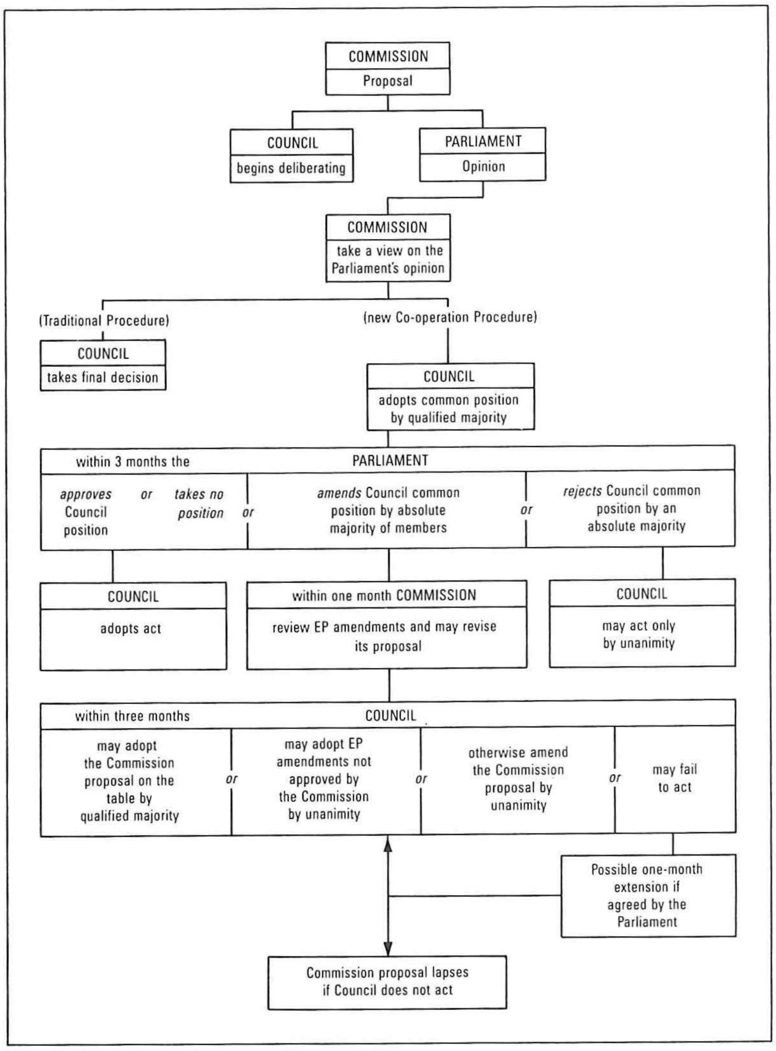


Figure 1—The EC and the British Government



EP: European Parliament

(Reproduced with acknowledgement to the Department of Trade and Industry)

Figure 2—Community legislative process—new co-operation procedure

tive and submits it to the Council of Ministers. The proposal is considered within the Council (only a qualified majority is necessary), this position taking account of Parliamentary opinion. Adoption of the common position is the major hurdle in agreeing a Directive.

The common position is then considered by the European Parliament. Unless the European Parliament amends or rejects the Council common position by an absolute majority of its members, the Directive is adopted. If the European Parliament either amends or rejects the common position, the consequent action is as illustrated in Figure 2.

THE EC DIRECTIVE ON EMC

The proposed EMC directive sets out two essential criteria:

- limitation of the generation of electromagnetic disturbances so as to allow other apparatus to operate as intended
- provision of an adequate level of immunity so that the equipment itself can operate as intended.

The Directive, which at the time of preparing this article (April 1989) had yet to pass all stages of the EC legislative process, follows a 'model' being adopted for the drafting of all Directives. The draft Directive is lengthy and inevitably legalistic in tone. Some of the key points are as follows:

- *Scope of Directive* This covers all electrical and electronic appliances together with equipment and installations containing electrical and/or electronic components. Where other specific Directives exist, the EMC Directive does not apply (see Article 2, page 2); for example, interference from motor vehicles etc. is covered in another Directive. However, certain existing Directives will be subsumed into this new Directive; for example, on electrical household appliances, portable tools and suppression of radio interference from fluorescent lighting luminaires.
- *Harmonised Standards* These are set by the European Committee for Electrotechnical Standardisation (CENELEC) and are called *European Norms* (ENs). Member States may transpose these into their own standards.
- *Placed on the Market* This requirement is defined in Article 3 and will present one of the major issues in the application of this Directive. The draft Directive states that all equipment that is 'placed on the market' after the operative date required by the Directive shall conform to the stated standards. The expression 'placed on the market' is open to a wide range of interpretation and can differ from the more usual UK expression 'point of sale'.
- *Immunity* Article 4 invokes requirements both for limitation of levels of disturbance generated by apparatus and levels of intrinsic immunity to interference. Unfortunately, CENELEC has as yet to issue standards to cover

immunity levels so this presents an interesting paradox. From 1992, all apparatus must conform to the Directive which may invoke a non-existent Standard!

● *Withdrawal from the Market* Article 9 requires that any apparatus not complying with the Directive after 1992 must be withdrawn from the market. This could have significant operational implications.

● *Third-Party Certification* Normally the manufacturer is required to certify that the equipment conforms with the Directive. However, Article 10 is of special significance to telecommunications. The Council considers that the high potential risk of electromagnetic disturbances by and to telecommunications terminal equipment, that is, network attachments, justifies a more severe procedure than for other apparatus. Therefore Article 10 para 4 requires a special third-party certification process for EMC on telecommunications terminal apparatus. Article 10 para 6 requires the notification to the Commission and Member States of competent authorities who will carry out this third-party certification.

● *The Technical Construction File* As stated previously, the Directive imposes compliance with Standards not yet in being. To solve this paradox, the concept of a 'technical construction file' is introduced (Article 10 para 2) which records the EMC performance of the equipment.

The requirements of the Directive can be met by the following routes to demonstrate compliance:

(*a*) show compliance to the ENs,

(*b*) show compliance to National Standards which transpose the harmonised standards, or

(*c*) where standards do not exist, record the apparatus performance in a technical construction file.

Figure 3 shows the paths that can be followed.

A more detailed review of the EMC legislation has been published by Dr Whitehouse of the Department of Trade and Industry (DTI)[1].

APPLICATION IN THE UK

In the UK, it is proposed to introduce substantial changes to Part II of the Wireless Telegraphy Act, 1949 in order to implement the Directive.

The current timetable required by the Directive is that Member States shall have their legislation in force by 31 December 1991 (the operative date).

From the 'operative date' onwards all 'apparatus and installations' which are 'placed on the market and taken into service' must comply with the EMC requirements.

The DTI view is that to meet the spirit of the Directive, 'placed on the market' shall apply not only to equipment first marketed after the 'operative date', but also to equipment which continues to be marketed after the 'operative date' even though it had been first designed and marketed for a substantial period prior to the 'operative date'.

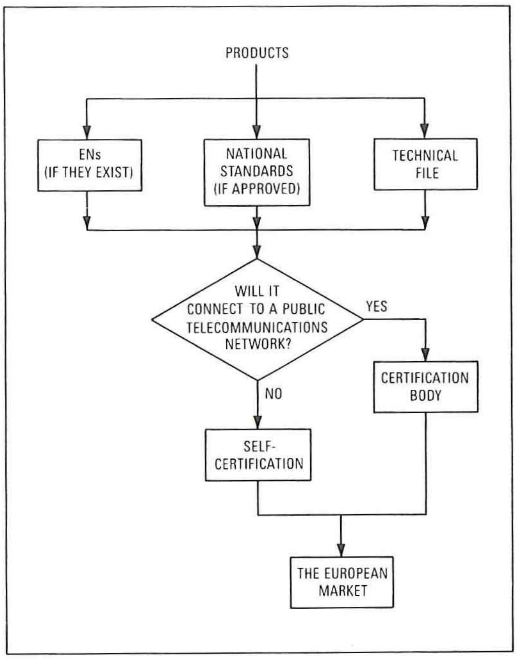


Figure 3 **Methods of compliance with the EMC directive**

This interpretation could have significant consequences for BT if current equipment designs which it is anticipated will continue to be purchased and brought into service after the 'operative date' do not meet the technical standards required by the Directive; for example, a substantial programme of design modification could be required with possible cost implications.

The Technical Standards relating to telecommunications and information technology equipment which exist relate specifically to emission levels and are embodied in the standard produced by CENELEC and issued as European Norm EN 55022. Within the UK, the British Standards Institution (BSI) will transpose the EN and issue BS 6527 which will be identical with EN 55022.

BS 6527 defines two classes of equipment; Class A (commercial) and Class B (domestic).

Class B is a much more onerous requirement. The decision as to what class an item of equipment falls into will be determined by the question 'For what sort of location was the apparatus primarily marketed?'

IMPLICATIONS FOR BT

Given the current state of uncertainty on some of the technical aspects of the EEC Directive it is difficult at this stage to give a quantitative assessment of the impact of the Directive on BT in its plant acquisition and provisioning activities. Some basic points, however, are as follows:

● Given that most current generations of equipment were not designed with the EMC standards in mind, a substantial programme of testing and evaluation has to be put in hand.

- It is certain that many products will not, as currently designed, comply with the new standards and some adaptation to equipment and changes of installation practice are unavoidable.
- In particular, a major technical reservation is the practical measurement to the prescribed standards for large telecommunications installations in operational buildings.
- Adaptation, such as screening of existing designs and changed installation practices could impose additional costs.
- On Network transmission equipment, a new equipment practice has already been sponsored, to be called *Type 88*, to meet the EMC requirements.
- On the positive side, however, the process of basic redesign gives the opportunity for more cost-effective realisations and there may be no cost penalty in such circumstances; that is, any increased costs due to EMC requirements can be offset by advances in component technology.

Overall, therefore, the new legislation could have significant implications for BT. Subsequent articles in this series consider some of the technical aspects of EMC and describe in detail the new Type 88 equipment practice.

ACKNOWLEDGEMENTS

The author acknowledges the advice received from colleagues in BT and from many discussions with the DTI, in particular Dr Alan Whitehouse, Deputy Director Radio Communications Division of the DTI.

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Biography

Bob Martin-Royle joined the Post Office in September 1952 as a Youth-in-Training in the City Area of the then London Telecommunications Region. He served with the Royal Air Force from 1954 to 1956. From 1956–1959 he worked on Exchange Construction and PABX installation. In 1959, he was appointed Assistant Executive Engineer via the Civil Service Open Competition. After a short period in Training Branch preparing correspondence course material he joined the Microwave Radio Section of WI Branch where he was involved in planning the rapidly expanding microwave network. He was appointed Executive Engineer in 1964 and assumed responsibility for installation and commissioning of microwave systems and was closely concerned with the opening of the London and Birmingham Telecom Towers. He was appointed Level 3 in 1968 and Level 4 in 1973. In 1977, he moved to the line system activities of the network and became Project Manager in 1978 for the introduction of optical-fibre systems. He was appointed to Level 5 in 1979 and became Deputy Chief Engineer in 1986. He has special responsibility for all works activities in the network and chairs the BT Steering Committee on EMC. He holds the Diploma in Electrical Engineering, is a Chartered Engineer, Member of the IEE, Fellow of the British Institute of Management and Affiliate Member of the Institution of Occupational Safety and Health.

Electromagnetic Compatibility—Its Impact on Telecommunications

A. J. SLATER†, and B. JONES*

This article, the second of a series on electromagnetic compatibility (EMC), points out the need for EMC in the design of telcommunications and information technology equipment. It goes on to review British Telecom's EMC test facilities and consultancy service, and the structure for defining immunity standards. Finally, it discusses the various types of interference to be taken into account.

HISTORY

It is often assumed that the rapid advances in electronics that have so radically altered the size, functions, and appearance of many items of information technology equipment, which includes telecommunications equipment, have been achieved without any detrimental change to the inherent performance of these products. Unfortunately, this has not been the case. The ability of equipment to resist interference from outside sources has tended to diminish as the complexity of electronics has increased, and in some situations digital equipment has been a source of interference to others.

The digital technologies now being used by the information technology and telecommunications industries have been converging for a number of years. For example, the complexity of telecommunications equipment located in the customers' own premises has increased to a level where the digital processing power contained within a small private branch exchange (PBX) is on a par with that of the personal computer (PC). However, one major difference still remaining is the analogue circuitry required by telecommunications systems, where signal-to-noise (interference) ratios in excess of 50 dB are required.

Over the past few years, as equipment has developed, logic families with a much lower noise immunity have been introduced. This is due in part to the increased use of high impedance inputs to save power and of wide bandwidths to increase speed, and to the use of low rail voltages. The net effect of these developments has been a reduction in the inherent ability of equipment to survive under operational conditions. This reduction in immunity has occurred gradually over a period of time and has been assisted by a lack of awareness by some designers of the importance of these parameters. This is now changing, and product managers throughout the information technology and telecommunications industries are now realising that they need to incorporate sound electromagnetic compatibility (EMC) practices into their products.

TELECOMMUNICATIONS EQUIPMENT

The availability of low-power dedicated integrated circuits (ICs) has enabled equipment design to develop rapidly. The mainly electromechanically-based public switched telephone network (PSTN), with telephone instruments of similar technology, has now been largely replaced by new sophisticated digital exchanges and transmission systems, allied with customer premises equipment which uses microprocessors extensively.

The telecommunications industry has always, for reasons of cost as well as technical performance, installed a large amount of unscreened twisted-pair cabling for its local distribution network. Consequently, the large number of input/output (I/O) lines used on even the smallest digital PBX has given any interfering signal present in the environment ample opportunity to gain access to the equipment. Additionally, the use of digital signalling techniques on this type of cabling can cause interference to licensed radio communications.

The simplest item of equipment on the public switched network is often considered to be the telephone instrument. The population of this item is many millions, and it provides the main access point to the public network. Improvements to the features available on these instruments have been made over the past few years with the addition of clocks, memories, displays etc, but its functions still appear simple when compared to the complexities of computer equipments. However, because of the size of the installed base, a large number of sets are subjected to many different sources of interference, and protection against the majority of them is necessary if basic service is to be provided.

The enhanced computing power available within terminals enables the provision of features such as last-number-redial memory, ten or more number stores, real-time clocks, alarms,

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* Quality and Reliability Centre, British Telecom Procurement, Strategy and Network Services.

call timers etc. If a mains power supply is added, the design of this type of equipment can be further enhanced to provide personal work stations and, ultimately, complete electronic office systems. With all this stored information now within the equipment, emphasis must now be placed on protecting it from hazards that can occur at any time during its service life, and not only whilst making calls.

DIGITAL EQUIPMENT

Because of the wide use of digital techniques, information technology equipment has possibly enjoyed a higher inherent immunity to radio-frequency interference (RFI) than analogue-oriented telecommunications equipment. Signal cables which leave the central processing area have in the past been screened to reduce unwanted emissions and maintain the matching impedances necessary at high data rates. However, in the electronic office environment, twisted-pair cables for local area networks and other digital signalling purposes are now being introduced.

If, as part of the precautions taken to reduce spurious emissions, the coupling between the internal digital processes and external lines has been kept to a minimum, interfering signals entering the equipment via these cables should not couple freely into sensitive areas within the equipment. However the I/O circuits themselves still need to be immune in order to keep error rates down to an acceptable level. One potentially weak area in computer systems is where information is held on a magnetic medium. During the writing or reading of this information, low-level analogue signals are being used and corruption of data is possible.

DEVELOPMENT OF EMC TEST FACILITIES WITHIN BT

With the introduction of the new 'all-electronic' telephone instruments in the early-1980s, their sensitivity to RFI and lightning was recognised and a small team of engineers started to investigate the problems of audio rectification and surge protection at the Research Laboratories at Martlesham Heath.

It was not long though before other product designers started to look for expertise and advice on EMC and so the number of products that this small team were looking at began to grow. It was on the basis of this work that the EMC Engineering Group was formed to provide consultancy and EMC test facilities for the whole of British Telecom.

With the publication of BS6527, in 1985, which described limits and test methods for radio-frequency emissions of information technology equipment, proposals were made to construct an open area test site to perform these measurements at Martlesham Heath (Figure 1). This facility, which has been operational for over two years, is one of the most sophisticated of its kind in the UK. An all-weather cover provides protection from the elements for both the equipment under test and the test antenna for measurement distances of up to 10 m. An underground laboratory houses the test receivers and any equipment used to exercise the equipment under test.

The facility was registered with the Federal Communications Commission (FCC) in the USA in October 1987 and so is capable of providing the necessary test documentation for the certification of products destined for the North American markets of the USA, and more recently Canada.

In addition to the test site, the EMC Engineering Group has two absorber-lined screened rooms for the immunity testing of equipment to electromagnetic fields (see Figure 2). A separate screened control room houses the measuring instrumentation. The Group also carries out tests for the effects of electrostatic discharge, lightning transients and interference on the mains supply.

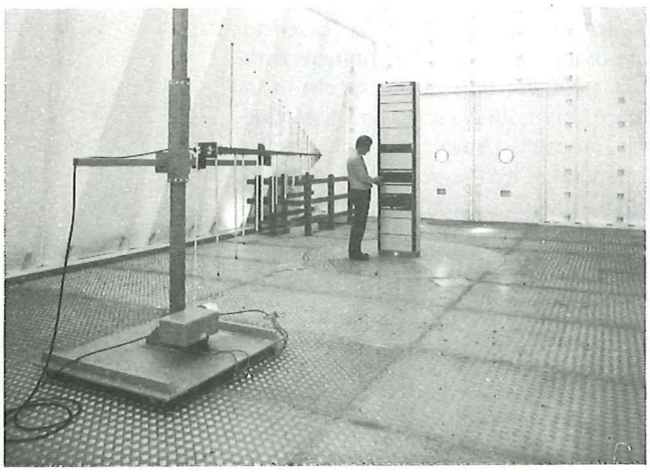

Figure 1—Open area test site

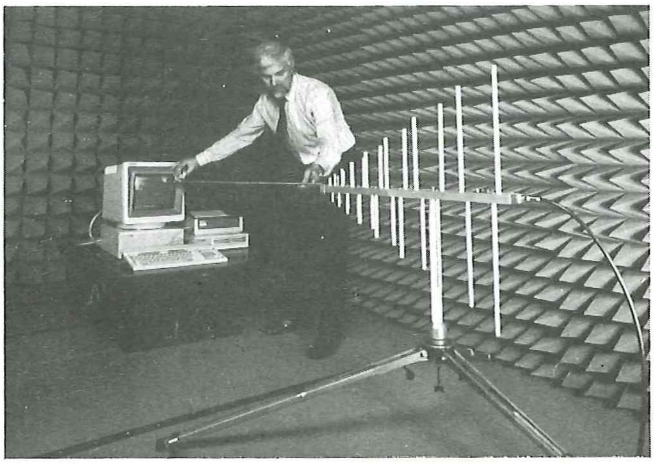

Figure 2—Radio-frequency anechoic chamber

Recently, the Group became accredited by the National Measurement Accreditation Service (NAMAS), a scheme operated by the National Physical Laboratory for the Department of Trade and Industry (DTI), for measurements to a wide range of EMC standards.

To meet the growing need for EMC testing and consultancy, the activities on lightning protection and ESD in the then Materials and Components Centre were augmented by radiated measurements using a radio-frequency anechoic chamber in 1985.

Further developments are now taking place, and work will start shortly on an all-weather open area test site in the countryside south of Birmingham. This will have separate basements for the measuring equipment, and the systems necessary to drive the equipment under test. A 5 m turntable will be installed in the ground plane (which will measure 20 m by 12 m) to enable all but BT's largest systems to be tested. The anechoic chamber will also be moved to a new building close to this site.

The Quality and Reliability Centre obtained NAMAS accreditation in February 1989 for a wide range of testing on components, materials and systems. In the EMC field, the accreditation covers conducted, radiated and electrostatic measurements to a wide range of D10000, national, international, commercial and military standards.

Together with the test facility at Martlesham Heath, these facilities offer the company an extremely comprehensive test and consultancy service, which matches the needs of the business as EMC becomes ever more important, particularly in the forthcoming regulated environment of the European Directive on EMC[1].

THE ENVIRONMENT AND STANDARDS

In order to ensure that equipment functions properly in service, immunity standards must be defined to reflect the environment. These describe the conditions the equipment will be expected to operate under, and specify the level of disturbance that can be tolerated whilst interference is present. This might be in the form of a maximum error rate, or a threshold where a system reset occurs.

To make the EMC Directive usable, a number of European standards must be agreed in time for the beginning of 1992, the date when the Directive comes into force. The European standardisation body that has been charged with this task is the European Committee for Electrotechnical Standardisation (CENELEC). In February this year, a new Technical Committee (TC110) was formed to supervise the work on EMC and to produce the necessary standards in what is a relatively short time. Its main task is aimed at producing a series of generic standards for application to a range of products and to concentrate on the production of an immunity standard for information technology equipment. BT is fortunate in having representation in the UK delegation contributing to this important task.

Within BT, a series of standards is being written, taking into account the work being undertaken in international forums.

In 1985, the then Materials and Components Centre, with the agreement of the Services and Network Standards Committee, set up an EMC Working Party, drawing membership from all parts of the business, to discuss EMC problems and write company standards. This is also the technical committee responsible for the co-ordination of BT's input to the national and international EMC committees, and as such complements the work of the EMC Procurement Steering Group which looks at the political and commercial implications of the forthcoming EMC Directive.

The EMC Working Party, now reporting to the Hardware Standards Expert Group, has produced a wide range of EMC standards for use by all parts of the business, and a series of guidance documents for use by product managers and design teams. (The latter documents are available to BT staff only.)

Lightning

Protection of telecommunications equipment from lightning induced surges on the network has been of concern to designers for some time. With more information technology equipment being connected to the PSTN, and twisted-pair cables being used for local area networks, the traditional data processing industry is also becoming concerned about the effects of this kind of transient. Studies have been undertaken to define the magnitude and waveshape of the resulting transients in overhead and buried cables. The results of the telecommunications-related work has been incorporated into international standards published, for example, by the CCITT. Further studies of the magnitude of lightning-induced transients into the wiring in tall buildings is being carried out by a number of organisations around the world.

Radio-Frequency Interference

Radio-frequency interference (RFI) is poised to become more of a problem to all equipment with the release of a greater part of the spectrum in the near future for mobile radio, and the wide use of RF in industrial processes. The intense local fields generated by the proximity of hand-held and vehicle-mounted mobile radio transmitters are the most likely source of RF energy to be encountered by most office systems. For example, taxis, and other mobile transmitters travelling down the high street, often come within 5 m of first floor offices. At these distances, field strengths in the range 1–5 V/m are generated, and as a high percentage of these radio systems still use amplitude modulation (AM), any non-linearity results in the detection of intelligible speech, which is both annoying for the telephone user and a security hazard for

the mobile operator. On computer equipment disturbance to visual displays may occur.

Commercial broadcast stations are another potential source of interference. These large transmitters can generate moderate field strengths over distances of a several kilometres. With the large amount of overhead wiring used by the telecommunication and power industries, a hazard exists when efficient coupling of these RF signals occurs. Measurements made near to transmitters have recorded RF voltages of up to 300 V on overhead telecommunication lines. However, typical levels at a 2 km radius are at a much lower level. During this study it was also discovered that large differential, as well as common mode, voltages can be found on telecommunication and mains power cables.

Industrial, scientific, and medical radio sources, for example, those used for welding metal and plastic in industry, and for diathermy in hospitals, also produce intense RF fields over considerable distances. Working at a frequency around 27 MHz, these signals are likely to couple efficiently into shorter interconnect cables. With the increasing number of high-density industrial estates made up of small factory units, it is highly probable that one or more will be using one of these processes.

Interference to a company's communications or computer system is often crippling to its commercial operation, frequently corrupting computers as well as interfering with audio circuits, thus rendering systems useless during normal business hours. Immunity to field strengths of 3 V/m is one of the recommendations in standards such as the IEC 801 series, which have been written to ensure that industrial process control equipment is unaffected by this type of environment. As information technology and telecommunications equipments are expected to operate in the same locations, similar immunity levels are being considered by these industries.

The International Special Committee on Radio Interference (CISPR) formed a sub-committee dedicated to studies relating to information technology equipment (sub-committee G) in 1986. One of the aspects to be addressed by a working group is the immunity of information technology equipment. One of its first tasks is to review existing standards on RFI and to make recommendations.

Electrostatic Discharge (ESD)

There is great activity in researching the mechanisms of ESD, and how to accurately simulate these events when testing equipment. ESD is likely to damage a component during the manufacture of equipment, although it may not actually fail until the product is in service. Unlike the very dry cold winters of North America, the English climate tends to be more benign due to a higher average humidity. Only during protracted periods of the coldest weather do the severe levels of electrostatic charges experienced in North America and the Continent occur. However, the increasing use of synthetic carpets and clothing has raised the average level of static charge carried by personnel to a point where problems to equipment could be experienced if no precautions were taken.

As part of the process control equipment standards mentioned earlier, the IEC has published an ESD standard which gives guidelines on test methods and equipment thresholds. In practice, the existing standard has failed to satisfy the needs of the computing and telecommunications industries, and a review is taking place to address the concern many engineers have expressed about repeatability of testing and correlation to the natural event. A revised standard should be published in about one year. In the meantime, the European Telecommunications Standards Institute (ETSI) has recently agreed a recommendation on ESD for telecommunications equipment based on the IEC work which is now available.

Radio-Frequency Emissions

The levels of radio frequency emissions (interference) that information technology equipment is permitted to generate is detailed in the European Norm EN55022, published in the UK as BS6527:1988. The standard relies heavily on the work undertaken in CISPR and published as CISPR Publication 22.

Both conducted emissions onto the mains power supply and radiated emissions from the equipment's cabinet are described with limits set over the frequency range 150 kHz–30 MHz for conducted and 30–1000 MHz for radiated emissions.

Conducted emissions onto signal and telecommunications cables are currently under consideration in both the CISPR and CENELEC Committees with BT contributing to the work.

At present, radio-frequency emission is the only aspect of EMC for which a European standard exists for information technology (including telecommunications) equipment for use under the EMC Directive.

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1 MARTIN-ROYLE, R. D. Electromagnetic Compatibility and the 1992 Single European Market. *Br. Telecommun. Eng.*, Jul. 1989 (this issue).

Biographies

Andy Slater is Head of the EMC Engineering Group at the British Telecom Research Laboratories at Martlesham Heath.

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Type 88—A New Telecommunications Equipment Practice

C. JELLY†

This article describes a new equipment practice for the telecommunications industry, Type 88. The new practice takes into account the needs of modern systems and addresses the demands of the new European legislation for equipment electromagnetic compatibility.

INTRODUCTION

Rapid technological change has been a feature of the telecommunications industry for many years. Developments in component technology have resulted in systems ever decreasing in size but working at faster digit rates to support larger numbers of circuits. Such changes have placed stringent demands on the design of equipment practice to keep pace with these new requirements, and an orderly evolution of equipment practice has taken place.

Type 88 equipment practice, designed and developed by GEC Plessey Telecommunications Ltd. (GPT)*, replaces the current UK mechanical practice for transmission equipment known as *TEP-1(E)*. This new practice has taken account of latest systems engineering needs and has also addressed the new regulatory requirements for equipment electromagnetic compatibility (EMC) described in accompanying articles in this issue of the *Journal*[1, 2].

LIMITATIONS OF PRESENT EQUIPMENT PRACTICE

Systems designed in TEP-1(E) equipment practice[3] have been in operational use for some 6–7 years and, in general terms, the practice has successfully met the operational criteria which were established at its conception. However, inevitably, some factors have emerged which require improvement to meet the needs of new systems and the evolving operational needs of British Telecom.

One principal limitation of the TEP-1(E) equipment practice is its almost total lack of electromagnetic screening. The construction consists of unscreened cards slid into shelves, which are mounted into an open structure rack. While this provides an efficient electronics packaging arrangement within an internationally recognised rack size, there is no provision for overall EMC screening of the rack or shelf, and hence any screening of particularly sensitive systems has had to be customised for particular product applications. This lack of electromagnetic shielding has caused particular difficulties to digital equipment with its fast-rise-time pulses which generate high-frequency interfering harmonics and low threshold voltage levels which are susceptible to externally generated noise.

Compared to EMC considerations, the other limitations associated with the TEP-1(E) design assume smaller importance; however, these are summarised below:

Cabling Considerations

The increasing use of LSI technology in new generations of transmission systems has led to further volumetric reductions in equipment. Typically, a new generation design more than doubles the number of equipments that can be accommodated on an equipment shelf. Hence, the number of cables necessary to serve equipment input/output ports per shelf is rapidly increasing and, as a consequence, the cabling/electronics volume ratio made available in the rack needs to increase.

Alarm Displays

Although service alarms are repeated on an end-of-shelf alarm display in TEP-1(E) practice, it has been found to be a disadvantage for maintenance personnel not to have visibility of alarm displays individually on the front of each printed circuit card. Any new practice will require such visibility across the full width of the shelf.

Electrostatic Discharge (ESD) Protection

Earthed wrist strap connection points for static discharge protection need to be provided at rack mid-height position for the use of commissioning and maintenance personnel. This is not a current feature of TEP-1(E).

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† Network Systems Engineering and Technology, British Telecom UK

* Type 88 equipment practice was developed by GPT on behalf of a number of telecommunications equipment manufacturers. All intellectual property rights in respect of this development are owned by GEC Plessey Telecommunications Limited and a further patent has been applied for. Other manufacturers have been licensed to use the practice, as has British Telecommunications plc.

Use in Customers' Premises

The TEP-1(E) shelf width is not compatible with 19 inch cabinets and housings which are preferred for customer equipment installations. The increasing need to provide equipment designed for BT network use in customers' premises has thus necessitated the supply of special cabinets capable of accommodating the wider TEP-1(E) and variant equipment practice shelf sizes. Inevitably, the need to supply expensive special cabinets will impact on the cost of service to the customer.

AC Mains Wiring

AC mains socket outlets are currently provided in rack footplates to power test equipment etc. The TEP-1(E) rack design does not offer economic wiring installation for this mains facility.

All the foregoing disadvantages have been addressed in the new Type 88 equipment practice.

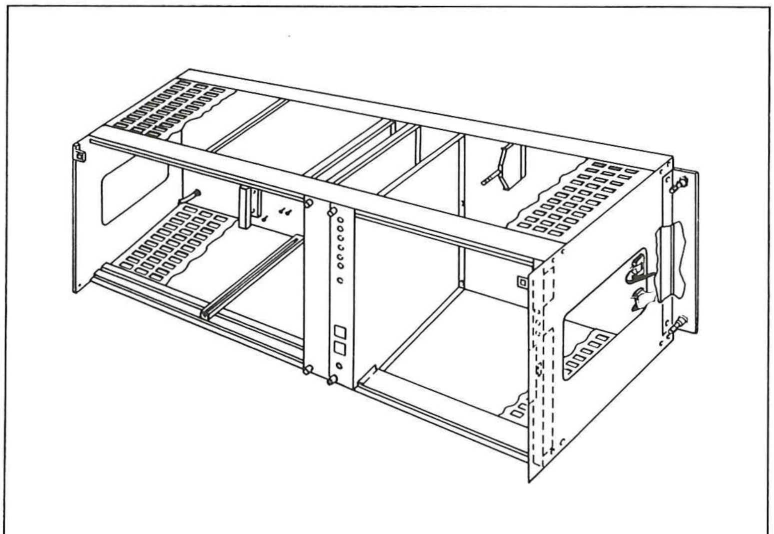
TYPE 88 EQUIPMENT PRACTICE

Recognising the need for future equipment designs to meet the impending European EMC legislation, GPT offered to develop a new equipment practice, now known as *Type 88*, on behalf of BT and the UK telecommunications transmission industry. An agreed set of target design objectives for the new practice was drawn up in conjunction with BT, and licences granted for BT, equipment manufacturers and specialist metal fabricators to make and use the practice.

Design

The unit of provision for transmission equipment is based upon a shelf which may house one or more equipments of the same, or similar type. Additionally, there are major planning and installation benefits to BT in the ability to fit shelf equipments of different manufacture in the same rack. For these reasons, the electromagnetic shielding boundary was chosen at the shelf level in order to ensure that adjacent equipment within the rack would not mutually interfere.

Figure 1
Type 88 shelf



The shelf design to emerge from this decision is a totally enclosed structure (that is, a Faraday cage), manufactured from aluminium extrusions and sheet metal in which the bottom and top screens are perforated to allow vertical air flow. (See Figure 1.) Cards or slide-in units (SIUs) are fitted with a metal front plate, each of which is in electrical contact with its neighbour by means of a metallic gasket. By careful printed circuit board track layout and component placement it is not normally necessary to screen between SIUs; however, where circuits are known to be especially sensitive because of low signal levels, on-board screens can be added. Dummy front plates may be used to complete the screened enclosure around unoccupied sections in a partially equipped shelf.

The EMC performance of the shelf is critically dependent upon the closure of unwanted gaps in its construction and the use of suitable finishes whose conductivity does not degrade with time. The assembly of pieceparts making up the shelf has been designed to meet these criteria.

Aperture sizes and thickness of the shelf top and bottom screens have been optimised in relation to transmission systems operating in the range 2 to 140 Mbit/s and in relation to maximising the flow of convected air through the systems. The measured screening effectiveness of the shelf structure in incorporating various aperture sizes is in good agreement with theoretical prediction.

System power and signal earths are both potential carriers of conducted noise into, and away from, the equipment. Particular attention has therefore been paid to the methods of earth connection at shelf level to give equipment designers maximum freedom to ground or isolate earths to suit the requirements of particular equipments.

Signal cabling connection to the shelf is achieved by means of extending the shelf enclosure to a connector 'field' mounted above or below the electronic shelf. Care has been taken to ensure that the screening integrity of the shelf is maintained with this arrangement. Alternatively, for equipment not occupying the full shelf width, the connector field can be co-located with the electronic cards, but the option for filtering and grounding must be retained.

Measurements have shown that, at frequencies between 30 and 300 MHz, the interface cabling, for example, power, alarm bus and signal wiring, is the principal cause of electromagnetic interference. Appropriate filtering arrangements are therefore essential at the equipment/cable interface and work is ongoing in this area to help identify the most effective and economic methods for use in production systems.

Cable Access

As indicated previously, equipment packing density significantly increases with each new generation of system bringing with it the problem of increasing cable density. By retaining the internationally recognised rack width at 600 mm, but reducing the shelf width compared to TEP-1(E), more space has been made for cable installation, obviating the need for external cable ducts currently in use. The use of a new miniature coaxial cable currently being introduced for transmission cabling will also assist in easing cable congestion problems.

Compatibility with other Construction Practice

Reduction in the shelf width dimension has also presented the opportunity to harmonise it with the 19 inch shelf width standard such that a Type 88 shelf may be fitted in a 19 inch rack by means of suitable adaptors. The ability to fit standard network products in 19 inch racking without the need for expensive special cabinets is seen as a particular advantage for customer premises application.

A further operational advantage of the Type 88 shelf is that it is capable, by means of adaptor brackets, of fitting into TEP-1(E) racking. This means that unoccupied shelf positions in existing TEP-1(E) racks may be equipped with new-generation systems designed in Type 88 to give greater flexibility to station planners.

The current TEP-1(E) card size of 195 × 222 mm has been retained for Type 88 application although no reason is seen why this should not change in line with international trends, for example, Double Eurocard size, as the practice evolves for future application. Also, the basic TEP-1(E) range of connectors has been adopted for Type 88 although some special EMC filtered and screened versions of the alarm bus and power interface connectors are under consideration.

Power Wiring

In order to avoid the possibility of noise injection into equipment due to induced transients from the −48 V supply line and its ground return, it has been decided to wire all Type 88 DC supplies as a balanced twisted pair directly to the electronics shelf. It is confidently expected that this arrangement will overcome noise problems encountered with earlier practices due to the on/off switching transient of DC/DC convertors on one shelf causing interference to equipments on adjacent shelves.

Maintenance Facilities

Card-mounted alarm displays in the new practice have been made visible for maintenance personnel by the use of transparent plastic front covers. The need for removal of shelf covers for fault diagnosis is thus eliminated.

Conveniently situated ESD wrist strap connection points with associated 'smudging' resistors have been fitted at the rack front. These are for use of commissioning or maintenance personnel who are required to discharge static charge that may be present on their bodies or clothing before removal of shelf covers for access to electronic SIUs.

The rack base has been redesigned to allow an easier wiring method for AC mains socket cabling.

Thermal Management

Unfortunately, shielding to meet EMC requirements is incompatible with the need to maintain unimpeded free flow of convected air for heat dispersion. Measurements have indicated, however, that the capability of Type 88 to dissipate heat by natural means has not been seriously

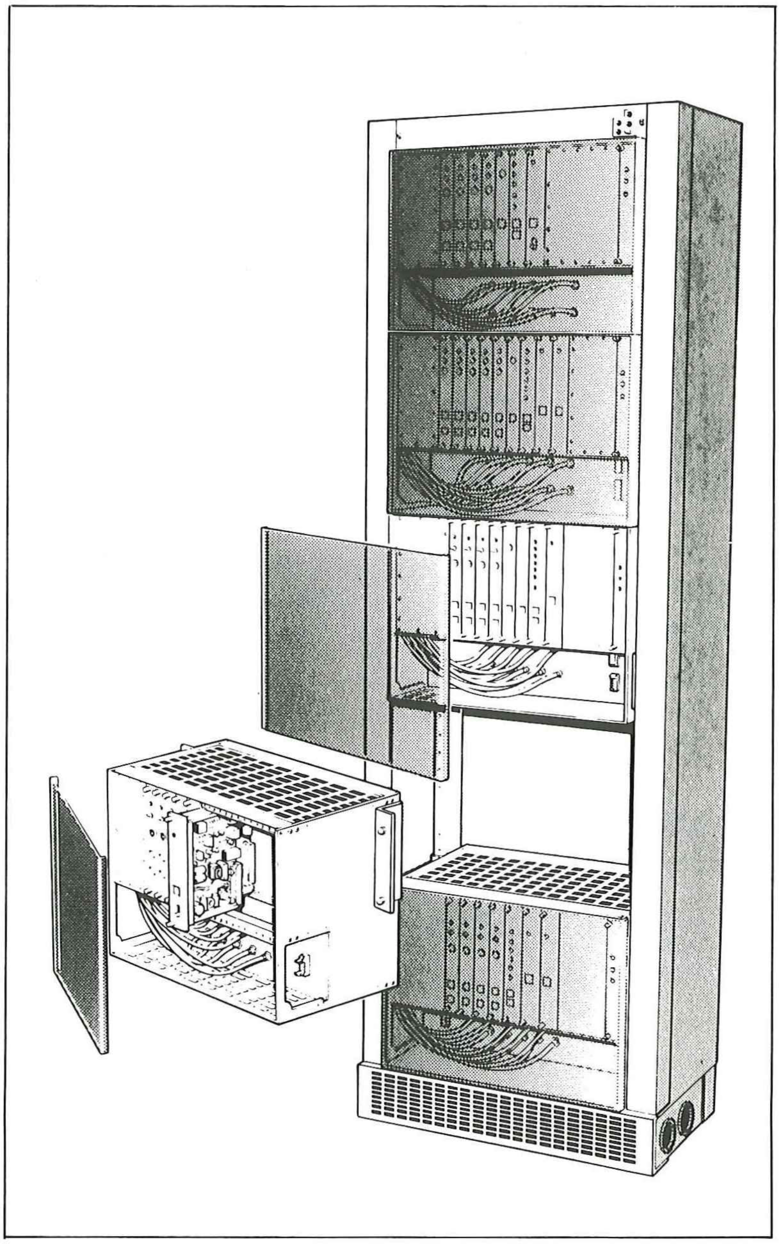


Figure 2
Type 88 rack

degraded compared to conventional open construction practices.

For high-dissipation shelves, convected air cooling can be supplemented by additional measures such as heat sinks on card front panels and heat dispersing 'metal sandwich' laminates on cards. Assisted cooling by means of fans may be permitted as a means of enhancing equipment reliability.

An overall view of the Type 88 rack fitted with shelves and covers is shown in Figure 2. In this illustration, the signal connector field is shown mounted below the electronics shelf.

CONCLUSIONS

A new equipment practice has been developed for use in the design of telecommunications equipments where the level of electromagnetic emissions and susceptibility needs to be controlled to meet the objectives of new European EMC legislation. The structure provides an electrical screen as well as the mechanical means of mounting cards used in a system, together with the necessary filtering and earthing. By using this practice, designers are offered the means of achieving the requisite levels of emission/susceptibility when used in conjunction with sound electrical engineering design principles.

In addition, other aspects of the new practice have been considered in order that the requirements for extra cabling space and accessibility, alarm display, thermal management, ESD performance and compatibility with existing systems are met. Mechanical pieceparts for the practice should be available from a range of skilled specialist fabricators.

ACKNOWLEDGEMENTS

The author acknowledges permission from GEC Plessey Telecommunications Ltd to publish this article and advice received from colleagues within British Telecom.

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Biography

Chris Jelly joined the then British Post Office in 1958 as a Youth-in-Training. He has been associated with transmission systems engineering since 1970 including responsibility for equipment hardware and environmental standards together with system specification authority for primary multiplex equipment. His present duties include transmission equipment practice specification and standards as well as BT co-ordination activities in relation to the harmonisation of equipment practice recommendations within Europe.

Plans for a British Trial of Fibre to the Home

T. R. ROWBOTHAM†

Plans for a trial of fibre to the home in Britain are now at an advanced stage. This article describes these plans. It outlines the reasons and objectives for the trial, the technologies to be deployed, and the proposed size and timing of the trial.

INTRODUCTION

Over the past decade, British Telecom has progressively digitalised its trunk network. All of its 53 trunk switching units are now digital and an all-digital trunk network is substantially complete. By 1992, BT expects that the junction network linking the local exchanges to the trunk exchanges will also be all-digital.

Today, a substantial proportion of this transmission network is optical fibre, some 600 000 fibre kilometres in all. Of this, about 7% is currently in the distribution or local loop side of the local exchange; that is, between the exchange and the customer. The spearhead of the drive for optical fibres between the local exchange and the customer is for that business customer base which has 25 lines or more. For this, the flexible access system has been developed[1], and will be expected to be deployed in substantial numbers over the coming years. However, in terms of fibre kilometres, this represents a very small proportion of the total transmission capacity of BT's network.

The flexible access system offers a number of advantages; not only does it offer service flexibility for today's range of network services but it has the potential to cater for new service offerings after it has been installed. At the same time, it has a comprehensive software control system of time-slots, circuit characteristics and electronics, together with built-in diagnostic features.

THE NEED FOR A TRIAL

BT's vision of the future UK telecommunications infrastructure comprises an all-fibre all-digital highly-integrated broadband network which incorporates both the main and local networks and which provides computerised end-to-end network management and control. A major step in the practical realisation of this BT vision is the provision of an integrated broadband network to replace the existing local loop. However, this network must be deployed on a commercially viable basis.

It is possible to envision the flexible access system becoming economic for smaller numbers of circuits to business customers as volume increases. However, the flexible access system is not designed for broadband services and even with the most optimistic projections of price declines with volume deployment it is unlikely to be economic for single-line telephony.

However, there are a number of alternative approaches being researched, broadly divided between those including switching/multiplexing between the exchange and customer (switched-star) and those based on passive optical networks. A field trial is part of the necessary process of learning whether the claimed advantages of fibre networks translate into practice.

The economic constraints are severe, and BT is looking for ways of overcoming these hurdles; hence, the need to explore the combination of broadband services and telephony over one network to obtain technical, operational and cost information to compare with conventional copper networks. This in turn leads to the requirement that such trials are implemented by the established operators and are conducted in a typical existing local network.

BT is currently engaged in a massive investment programme to upgrade cable and plant between the exchange and customer in its drive to further improve network availability and quality. Any measures which can bring forward new plant which has a measure of future proofing, while being operationally compatible with the remainder of BT's network, must be seized. This in turn has led to a requirement to hold a trial as soon as possible. The decision to proceed also coincided with the publication of the ACOST report[2] to the UK cabinet office encouraging operators to stage trials of multi-service optical local networks.

Trials are being held elsewhere, in particular in North America, but a trial in the UK was deemed essential in view of its different regulatory regime and network structure, even if the full information from other trials was available, which may not be the case.

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OBJECTIVES OF THE TRIAL

The above has led to the following objectives being set for the trial:

(*a*) to demonstrate the technical feasibility of using optical fibres in the local loop for single-line telephony customers;

(*b*) to allow comparison of active and passive architectures with regard to cost, technical performance and ease of operation and customer response;

(*c*) to give experience in practical operational aspects of the optical local network, including installation, moving of customers, reliability, maintenance and network control;

(*d*) to provide experience to allow projection of procurement and operational cost with greater confidence than at present; and

(*e*) to give BT first-hand knowledge to allow full participation in the world debate on topologies, technologies and standards for optical local networks.

LOCATION

A significant difference between these trials and those being conducted elsewhere is that the UK trials will take place in an area which represents a mix of housing and small businesses of different types and ages typical of the UK. It is not aimed at green field sites and it is not aimed at multi-line households.

The trial area needed to meet certain requirements:

(*a*) A suitable mixture of different types of housing and methods of providing service; for example, via poles or underground for the final drop to the customers' premises.

(*b*) Customers must be entirely serviced by a digital exchange and be equipped with an advanced version of the DASS2 signalling system in time for the trials.

(*c*) Adequate accommodation and resources need to be able to be made available by the BT District.

(*d*) The trial site needs to be outside an existing or prospective cable franchise area.

(*e*) The site should be easily accessible from British Telecom Research Laboratories (BTRL) at Martlesham and from London. BTRL is responsible for the detailed integration and engineering of the trial and Network Systems Engineering and Technology, BTUK, based in London, is responsible for the planning, installation and maintenance of the systems.

After considering a number of sites, Bishop's Stortford has been chosen.

Bishop's Stortford is a small self-contained town of some 12 000 houses. It is about 30 miles from London on the M11 motorway and on the London–Cambridge British Rail line. It is within 5 miles of Stansted Airport, currently being expanded to become London's third International Airport. The exchange is in the centre of the town directly adjacent to the railway station. It became fully digital in March 1989.

Several housing estates have been identified as suitable, radiating outward from the telephone exchange in various directions. Within these estates there is the required mixture of modern and older property with local feed either being overhead or directly buried underground. There is very little duct all the way to the customers' premises.

If required, there are green field housing estates existing on the edge of the town, while two business estates have been identified, one a large estate of 1950s–1980s industrial units and the other a brand new estate in the process of being established. Satellite antennas for the cable-TV head-end can be situated on the exchange roof.

SERVICES

The trial will demonstrate the provision of a variety of telecommunication services over an integrated network. The basic service package is as follows:

Telephony One circuit will be provided to each residential customer, with between 2 and 5 lines to each business customer. The initial telephony service is limited to analogue telephony only (loop-disconnect and MF4 signalling).

Broadcast TV At least 30 broadcast channels will be provided (subject to availability from service providers).

Stereo Audio 12–16 high-quality stereo channels will be provided, each broadband customer to have access to one at a time.

Videotex Broadband customers will have access to a local information server and gateway access to Prestel-like text services without requiring adapters for their TV sets.

This basic package will be supplied to customers to a roll-out plan described later in this article, but the opportunity will be taken during the trial period to add upgrade service packages to some of the customers or to a show house.

Candidates to such an upgrade include ISDN, hi-fi telephony, advanced TV standards including HDTV and access to a video library.

CUSTOMERS

The involvement of 'typical' customers is an important feature of the trial, but customers in the selected location will not be obliged to participate in the trial. Participating customers will retain a copper line to the exchange as a stand-by and telephony service will be provided over copper after removal of the trial equipment,

The trial is not seen as a marketing exercise since the commercial conditions will be totally unrepresentative. However, the demand for the various services may provide useful information for future system definition. Consideration is being given to the design of the equipment that will be located on the customers' premises to

ensure that it will be of an acceptable size and style, while allowing access for maintenance purposes, provision of a mains power supply and causing minimum disruption to interior decor.

NETWORKS

Two fundamentally different optical networks will be trialled. Optical local systems are classed as active or passive depending upon whether there is any active electronics between the exchange and the customer's premises. Each offers a range of different advantages. While most world-wide interest has, until recently, been on active systems, there is now a growing interest in passive networks. It has, therefore, been deemed prudent for the trial to include both types of system.

Passive Optical Networks

The passive optical network to be trialled is referred to as *telephony on passive optical network* (TPON)[3], and is a system design aimed at minimising the cost of using optical local networks to provide telephony (and other low bit rate) services alone, while allowing later upgrading to carry broadband services. The key features are outlined in Figure 1.

Each TPON system is designed to serve up to 128 fibre feeds to customers' premises, although for the proposed trial this will be limited to 32 (a key factor in this decision being the power loss due to passive splitting). For transmission from the exchange, the information for all the customers on the system is assembled into a time-division-multiplex format, and is broadcast at 20 Mbit/s over a tree-and-branch type network of monomode fibres. Each network terminating equipment (NTE) accesses its dedicated time-slot to gain incoming service. Outgoing transmission from the customer's premises is provided by a time-division-multiple-access system with each NTE transmitting bits of information at pre-arranged times. A timing protocol is used to keep each NTE synchronised to its assigned bit time-slots for both reception and transmission. The protocol also corrects for the different transmission delays of geographically spread customers. The 'go' and 'return' paths may be implemented on separate fibre trees, or on the same fibre tree using bi-directional transmission.

The NTE in Figure 1 can feed either one (residential) or a number of exchanges lines (business) to the customer. It is also possible to site the NTE in either the customer's premises or the street. In the latter case, a number of copper drops, one to each residence would be required. At the time of writing, the detailed planning of the layout of the plant in Bishop's Stortford has not been completed.

While TPON has been designed as one of the cheaper ways of implementing an optical network for telephony-only customers, it has also been made compatible with the later enhancement to *broadband passive optical network* BPON). A possible configuration for this is shown in Figure 2.

The broadband services are carried over the same fibre network as the telephony (TPON) but at a different wavelength, giving the equivalent of between 16 and 32 TV channels for each BPON wavelength used. A number of different wavelengths may be used to provide different

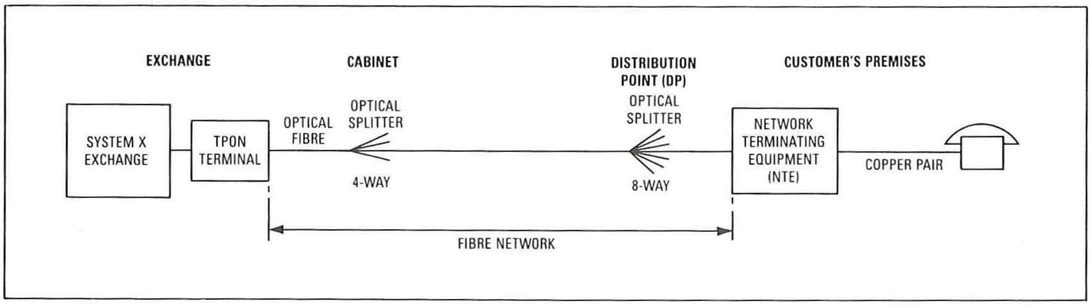


Figure 1—Single-line TPON

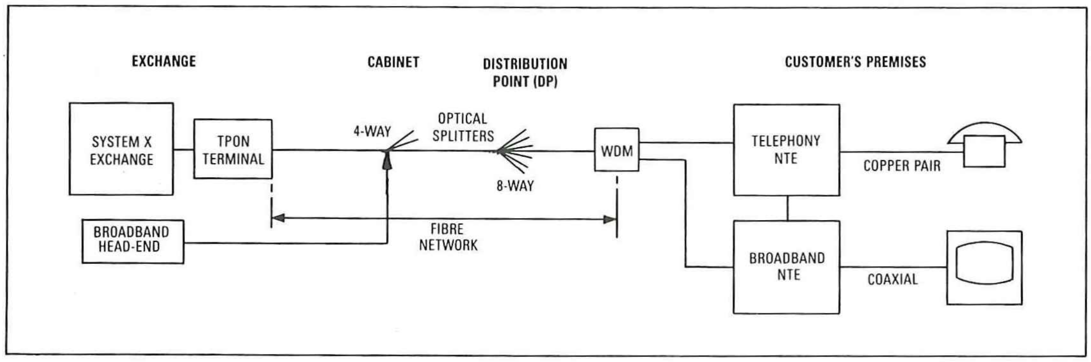
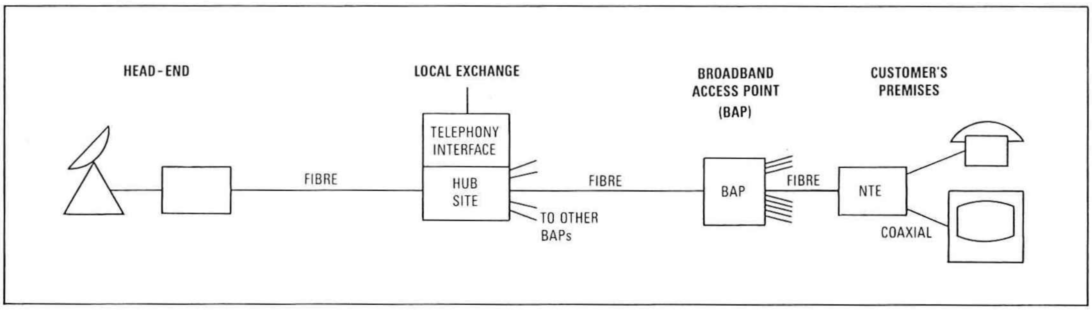


Figure 2—Single-line TPON upgraded to BPON

Figure 3
BIDS



services. No broadband upstream channel is proposed for the trials, but any narrowband upstream data for control and interactive services will be carried over the TPON channel.

Switched-Star Networks

BT's proposal for an active network is known as *broadband integrated distributed star* (BIDS) and is illustrated in Figure 3. The architecture is basically of star form (with a number of feeders radiating from the head-end) and it has switching at the broadband access point (BAP) so that each customer only receives the wideband channels that he/she requests. It is based on the cable TV switched-star network (SSN), but, in this case, a multiplexer is added to provide telephony, and the link to the customer is over monomode fibre. The BIDS network is based heavily on the BT design of switched-star network used for the Westminster Cable TV franchise area[4], but the design has been modified to allow the provision of telephony and to use fibre right up to the customer's premises. This type of system may be best suited to situations where a full integrated service is to be introduced with high penetration of broadband service from the start (whereas TPON is more suited to situations of evolutionary growth of broadband services).

Broadband signals from the head-end are transmitted to the hubsite (usually the local exchange) from whence they are broadcast to a number of BAPs. Each BAP is served by a number of fibres for video, telephony, stereo audio and control functions. Each video fibre carries 8 or 16 TV channels using analogue frequency modulation and an additional fibre carries stereo audio. Telephony is carried from the exchange to the BAP using digital transmission on separate fibre(s) and control information is conveyed on one of the video fibres on the stereo audio fibre.

In the BAP, the telephony for the individual customers is demultiplexed and the TV channels enter a switch of 48-channel capability. Each customer is provided with a fibre link from the BAP over which he/she receives telephony and two channels. The customer selects programmes for each channel by sending commands to the BAP from a keypad. The customer can also receive a single stereo audio channel.

Optical Plant

The optical plant required for TPON/BPON and BIDS networks includes transmitters and receivers, optical splitters and filters, cables of various types (underground and overhead), joint housings, enclosures and test equipment. One of the main purposes of the trial will be to evaluate the practical problems associated with using these components in the local network environment.

It is proposed that all the enclosures will be capable of using blown-fibre technology or proprietary cables.

Operations Support System

The software for system control and management represents a significant element of the design of a system suitable for carrying live service. An important element of the trial will be the study of the operational problems associated with this type of network. The operations support system will handle the following functions: service initiation, records and accounts, fault reporting and restoration of service, and traffic monitoring.

For the BIDS system, much of the operations support system developed for the Westminster SSN may be used with comparatively small modifications. The BPON network may be less compatible with the Westminster operations support system, although the experience gained and some of the system software will be useful for that too. Account will also be taken of the principles employed in the flexible access system[1].

SIZE OF TRIAL

While the exact scale and topology of the trial will depend on the detailed layout and customer distribution in the chosen sector of Bishop's Stortford, the proposed size for planning purposes is:

NETWORK TYPE	CUSTOMERS
Passive optical	240 residential (half on street TPON) + 32 business
Distributed star	240

It is intended that both networks will have broadband services to a proportion of the customers shown diagrammatically in Figure 4.

TIMESCALES

The timescales are summarised in Figure 4.

These timescales are demanding, but are considered necessary to meet the objectives outlined earlier. Detailed timescales for the various aspects of the project are still being refined, but the key interim milestone will be assessment of prototype equipment on test-beds at BTRL during the latter half of 1989.

It is currently envisaged that the trial network will be operated for about 2 years. The period must be long enough both to provide operational data over a representative period (summer and winter) and to make it attractive to customers who will have to undergo some disruption while equipment is installed and removed.

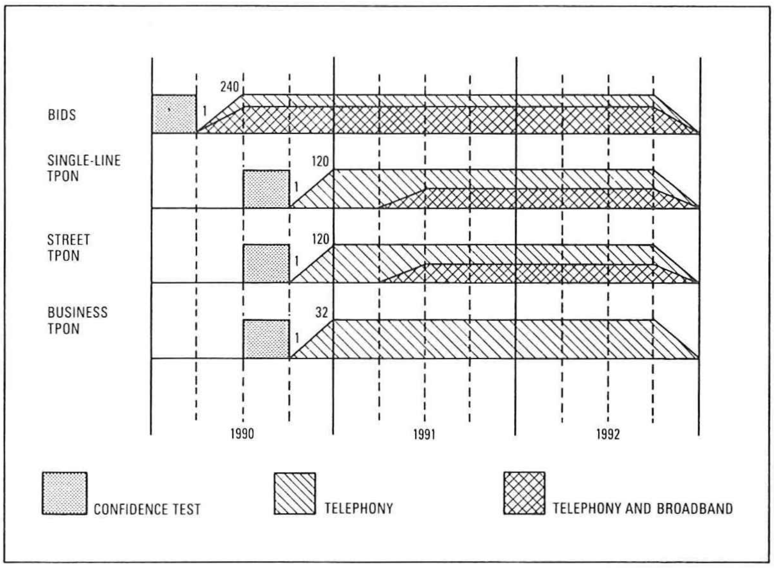


Figure 4
Summary of timescales for customer service

ACKNOWLEDGEMENTS

Acknowledgement is due to Bill Ritchie and his team for the planning of the technical aspects, and to Granville Taylor, who heads the deployment planning. Thanks are also due to Ken Fitchew who summarised the definitive trial proposals in a document from which this article is a digest.

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Biography

Tom Robotham obtained in succession a B.Sc. from Queen's University Belfast (1964), M.Sc. in Microwave Physics from University of Surrey (1968), and a Ph.D. in Modelling of Transient Phenomena from University of Nottingham (1978). In 1986, he was appointed to a Special Professorship at Nottingham University. He started his career with British Telecom in 1964 on satellite earth stations. In 1966, he became a Group Leader at Castleton Research Laboratories, South Wales, developing microwave integrated circuits. In 1974, he became Head of the Digital Transmission Research Section at Martlesham Heath, moving in 1979 to Washington DC as Section Chief in charge of Communications R&D for the International Telecommunications Satellite Organisation (INTELSAT). In 1982, he became Head of the Optical Transmission Research Division, in 1987 was appointed General Manager Network Systems, and in April 1989 he became Director Network Technology at BTRL.

Speech Codec for the Skyphone Aeronautical Telephone Service

I. BOYD, C. B. SOUTHCOTT, D. P. CROWE,† and P. J. BOLINGBROKE*

British Telecom International (BTI) has introduced an aeronautical telephone service known as the Skyphone. *This service uses 9·6 kbit/s speech codecs because of the limited satellite power available. Because of the need to achieve operation of aeronautical telephones between any aircraft and any ground station in any country, the technical specifications have been agreed internationally. After extensive testing of the various speech codecs proposed for the service by companies from several different countries, the codec designed at British Telecom Research Laboratories (BTRL) was found to be the best and is to be used both for international telephony and for air traffic control. This article gives a brief description of the Skyphone, and the factors which influence the speech codec design, and then describes the codec designed by BTRL for the service.*

INTRODUCTION

With around 1000 wide-bodied jets in service, several million busy executives traverse the world every year. For these executives, accustomed to mobile telephones and constant contact with their offices, it is unacceptable to be out of touch for the duration of long international flights.

As a first step to meeting this market need and providing improved communications between airlines and their aircraft, a consortium comprising British Telecom, British Airways and Racal Decca was formed to demonstrate in-flight telephone facilities. After technical trials during 1988, which successfully demonstrated telephony via satellite to an aircraft, a trial service was started in February 1989, providing two telephony channels to a British Airways Boeing 747 flying transatlantic routes. The service is being marketed by British Telecom International (BTI) and is called the *Skyphone* service. For this service, British Telecom is providing the earth station equipment at Goonhilly, the links through to the international telephone network and billing facilities. Racal Decca has provided the aircraft equipment required to set up calls, including the special aircraft antennas. The system uses a satellite of the INMARSAT organisation which currently provides satellite communications mainly for the maritime community.

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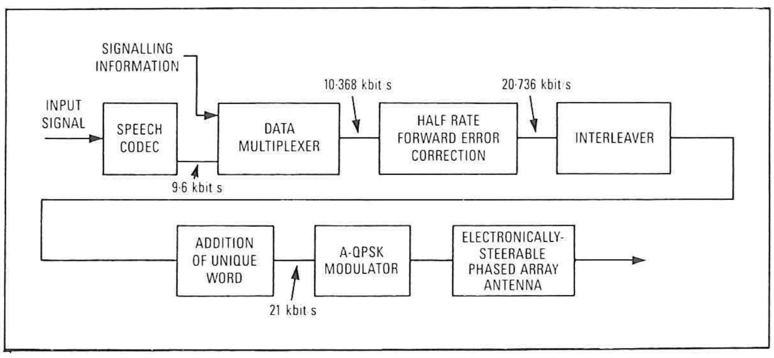
* Technology and Development Division, British Telecom International

Figure 1
Simplified block diagram of the aircraft transmission system



Later in 1989, the trial service will be replaced by an augmented fully-automatic operational Skyphone service conforming to the specifications agreed internationally. With the introduction of this operational service an agreement between British Telecom and the telecommunications administrations of Norway and Singapore will come into effect. This agreement will extend the Skyphone service to enable truly world-wide service to be offered, with telephony traffic from flights over the Pacific, Indian and Atlantic oceans.

Digital transmission is to be used between the aircraft and the BTI international exchanges. Low bit-rate speech coding has to be used because of the very limited satellite power available. After an international competition to select the voice coding system for global use, the British Telecom Research Laboratories (BTRL) speech codec has now been chosen by INMARSAT and has been recommended to the Airlines Electronic Engineering Committee (AEEC) by its specialist sub-group.

This article describes the features of the aeronautical system which affect the design of the speech codecs. The BTRL speech coding algorithm for the Skyphone service is then described and the implementation of the algorithm on a digital signal processing device is outlined. Finally, the performance of the codec, giving test results and discussing operational experience of its behaviour in the Skyphone system, is described.

SPEECH CODEC DESIGN FOR THE SKYPHONE SYSTEM

The main elements of the aeronautical satellite system are illustrated in Figure 1. The operating

bit-rate for the speech codec was selected as 9·6 kbit/s because no lower bit-rate codec examined by INMARSAT and BTI gave acceptable speech quality. Higher bit-rate codecs, while yielding better speech quality, were ruled out because of the limited satellite power available.

The data multiplexer is used to multiplex the output data stream from the speech encoder and some signalling information. The 10·368 kbit/s bit-rate of this combined data stream is doubled when forward error correction (FEC) is applied. The half rate FEC unit consists of a convolution encoder of constraint length seven: the corresponding decoder is an 8-level soft decision Viterbi decoder[1].

To combat the multi-path fading characteristic of the aeronautical transmission path, interleaving is applied to preserve the FEC coding gain by spreading burst errors throughout a transmission frame. A number of interleaved blocks are collected together and a 'unique word' and a few dummy bits are added to form a 0·5 s radio frequency (RF) frame (Figure 2) which is transmitted at 21 kbit/s. The RF demodulator synchronises itself with respect to the unique word. Loss of frame synchronisation is assumed to have occurred after the demodulator unique word match is below a prescribed threshold for two consecutive frames. A form of offset quadrature phase shift keying (O-QPSK), known as *Aviation-QPSK* (A-QPSK)[2, 3] is used to modulate the 21 kbit/s signal onto the RF carrier. The aircraft antenna for the trial service is an electronically-steerable phased-array antenna.

The bit stream presented to the speech decoder after errors have been introduced on the radio path and reduced by the channel coding has an average bit error rate of between 1 in 100 and 1 in 1000. There will also be bursts of errors when the error correction cannot cope. The speech codec must be able to suppress the effects of all of these. Particular attention was paid to the different types of transmission error in the development of the BTRL codec for the Skyphone system.

The physical environment in which the airborne codecs is expected to operate requires particular care in the design of the codec hardware. The equipment will be installed in a pressurised location within the aircraft but must, nevertheless, be tested to ensure reliable operation at the temperature extremes of −15°C and +55°C, at a pressure equivalent to an altitude of 15 000 feet, at 100% humidity and with severe vibration. The temperature range of this specification alone rules out the use of components with a normal commercial specification. In the hardware implementation, the use of components with a military specification, good component heat dissipation, low power consumption and reliable interconnection is therefore essential.

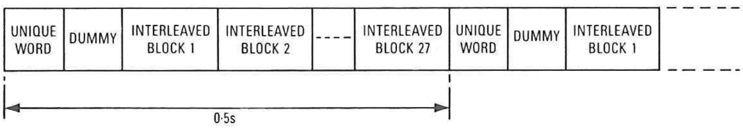


Figure 2
RF frame format

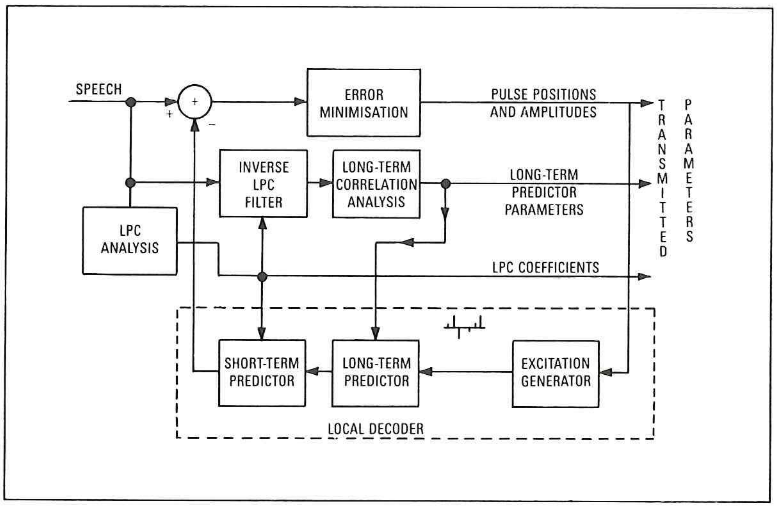
THE BTRL SKYPHONE SPEECH CODEC

Introduction

To achieve the spectral efficiency required for the Skyphone service, low bit-rate speech encoding is required. A multipulse-excited linear predictive coding (LPC) algorithm[4] was selected by BTRL as it is robust to background noise and transmission errors.

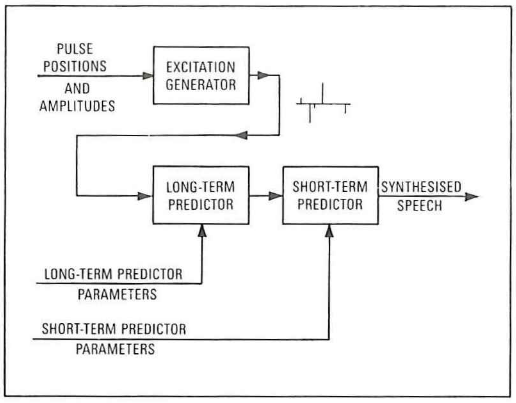
A schematic of a multipulse-excited LPC encoder is illustrated in Figure 3. The encoding process involves splitting the incoming speech into frames of 10−20 ms duration to derive the short-term and long-term predictor parameters and an analysis-by-synthesis process to obtain the pulse positions and amplitudes. The short-term predictor models short-term correlations in the speech signal. The long-term predictor takes advantage of long-term correlations in speech, primarily arising from pitch-related correlations in voiced speech.

Figure 3
Multipulse excited LPC encoder



The excitation analysis-by-synthesis procedure involves a search for the pulse positions and amplitudes which minimise the mean squared error between a block of the input speech and the speech obtained from the synthesiser in the local decoder. The derivation of the excitation may be carried out for the entire LPC block length, or the LPC frame may be split into several sub-blocks and the excitation derived for each sub-block separately. To find all the pulse positions and amplitudes simultaneously for a sub-block requires the solution of non-linear equations and is thus very complex. Sub-optimal methods have therefore been developed to derive the pulse positions and

Figure 4
Multipulse excited LPC decoder



amplitudes sequentially. A multipulse-excited LPC decoder corresponding to the encoder of Figure 3 is presented in Figure 4. The decoding process is very straightforward, requiring the formation of the excitation signal and the application of this excitation to the long-term and short-term predictors to give the synthesised speech output.

Short-Term Predictor Parameter Extraction

The short-term predictor parameters are obtained by using standard LPC techniques. The LPC analysis problem may be outlined with reference to equation (1) below:

$$E = \sum_{n}(s(n) - \sum_{k=1}^{p} a_k \, . \, s(n-k))^2 \quad \ldots (1)$$

where E is the mean squared error over a block of speech samples, $s(t)$ is a speech sample at sample point t and the a_k coefficients are a set of predictor coefficients.

The goal of LPC analysis is to derive a set of predictor coefficients such that the mean squared error E over the block is minimised. The block over which the error minimisation takes place is usually between 10 and 20 ms long and the order of the LPC analysis, p, is generally between four and sixteen. The minimisation of the error E is achieved by differentiating equation (1) with respect to each a_k value and solving the resulting simultaneous equations. Depending on the limits used in the summation of equation (1), the LPC analysis is either an autocorrelation or covariance analysis. Although the covariance analysis is more accurate than an autocorrelation analysis, the resulting synthesis filter is not guaranteed to be stable. An autocorrelation analysis guarantees the stability of the synthesis filter but requires the speech signal to be windowed such that the signal energy outside the block of interest is zero. A rectangular window is not generally very satisfactory and a tapered window, such as a Hamming window[5], is usually employed. For the Skyphone codec implementation, an autocorrelation analysis is used and each speech frame is windowed using a Hamming window. Durbin's recursion[6] is employed as an efficient means of calculating the predictor coefficients following the autocorrelation analysis.

Direct quantisation of the predictor coefficients requires an excessive number of bits to give a stable and accurate LPC synthesis filter. An alternative set of coefficients, the reflection coefficients, can be used instead of the predictor coefficients to specify the synthesis filter. These reflection coefficients are a by-product of Durbin's recursion and have the useful property that provided the modulus of each coefficient is less than one, the all-pole LPC synthesis filter is guaranteed to be stable. The predictor coefficients can be derived recursively from the quantised reflection coefficients at both the encoder and decoder[7].

The LPC analysis parameters adopted for the Skyphone codec implementation are:

- 10th order LPC autocorrelation analysis
- 32 ms Hamming window with 37·5% overlap
- predictor coefficient update period of 20 ms.

Long-Term Predictor Parameter Extraction

Long-term correlations in the speech signal are effectively represented by the long-term prediction filter (see Figure 5). This filter has a transfer function in the z-transform domain of:

$$P(z) = B.z^{-m}$$

where B is the gain parameter of the filter and m is the delay at which the maximum correlation occurs.

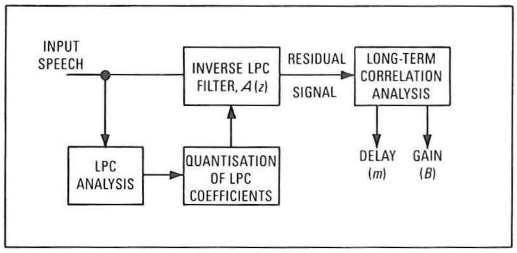


Figure 5—Long-term predictor parameter extraction

For the long-term predictor in the Skyphone codec, 64 delay values are searched for the maximum correlation. The delay and gain values are updated at the same rate as the short-term predictor coefficients; that is, every 20 ms. The gain value is quantised by using a non-linear quantiser and the delay value is encoded into 6 bits.

Determination of Pulse Positions and Amplitudes

The goal in deriving the pulse positions and amplitudes for an excitation sub-block is to minimise the mean squared error between the input speech signal and the synthesised speech

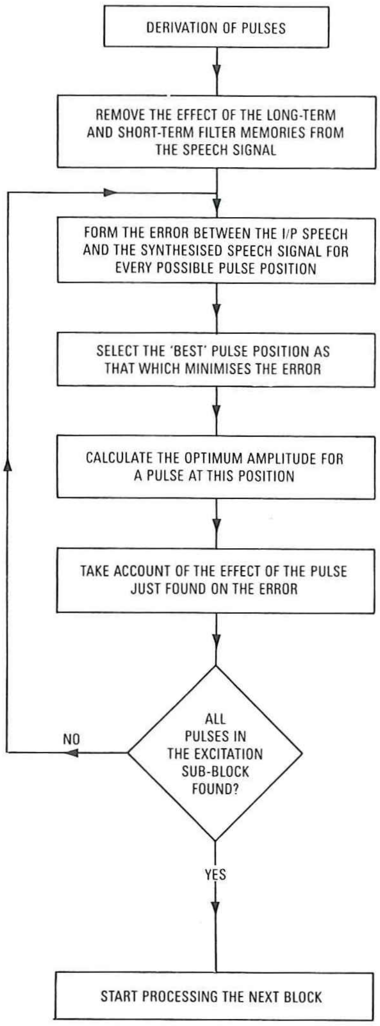


Figure 6—Operations for finding pulse positions and amplitudes

signal. The optimum solution of deriving all the pulse positions and amplitudes simultaneously is not feasible because of the non-linear nature of the problem. Therefore, sub-optimal solutions have been developed which find the pulses one at a time. This process is illustrated in Figure 6.

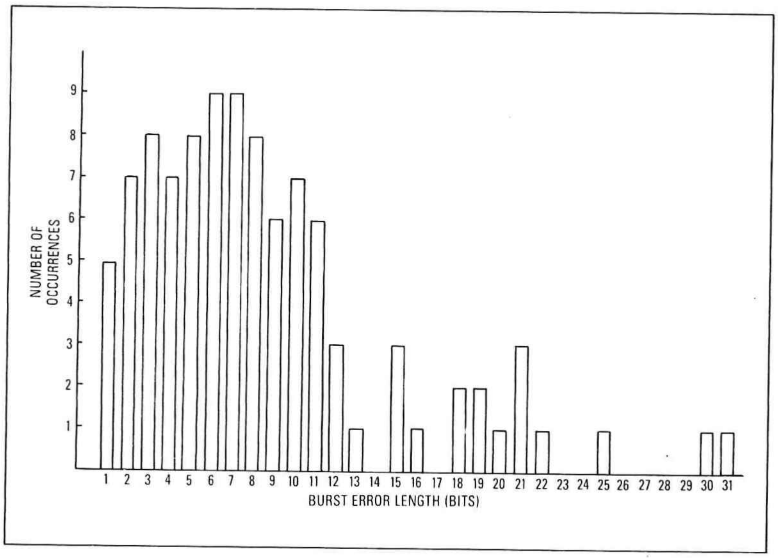
Error Protection

The Skyphone codec was designed to cater for two different error conditions:

- the expected random bit error rate of about 1 in 1000
- burst errors caused by breaks in the radio link due either to momentary misalignment of the aircraft antenna or poor propagation conditions.

It was found that, to maintain the speech quality of the error-free case for the random errors, forward error correction has to be applied only to the reflection coefficient information bits. With only a few hundred bit/s of the available 9·6 kbit/s data rate used for error protection, the codec maintains the required voice quality for a random bit error rate of 1 in 1000. During the worst propagation conditions the RF demodulator cannot maintain synchronisation: when this occurs the demodulator activates a codec squelch control signal. Unfortunately, the squelch control signal cannot be activated until two unique word matches are below a prescribed threshold. Thus, with a radio system frame size of half a second, up to one second of random data is passed to the codec before the squelch signal operates. The codec has to detect this situation, and other severe burst error conditions, and mute the codec output signal. Some of the transmission bits in the 9·6 kbit/s data stream have therefore been reserved for burst error detection. When a burst error is detected that lasts for up to one speech frame, 20 ms, it has been found that it is better, perceptually, to repeat the previous speech frame than mute the codec. If, however, burst errors are present for several consecutive frames, then the codec output is muted until no more burst errors are detected. Figure 7 shows the burst error distribution measured at the codec input during some recent flight trials. This distribution does not take account of the times when the demodulator lost synchronisation and burst errors lasting several hundred speech frames occurred.

Figure 7 Burst error distribution (measured over several minutes)



CODEC IMPLEMENTATION

The implementation of the algorithm described above is outlined in this section. As is normal for state-of-the-art speech codecs, the algorithm is implemented on a digital signal processing (DSP) microprocessor. The reasoning behind the selection of the particular DSP device for this application is presented below.

Digital Signal Processor

From previous experience of implementing speech codecs on fixed point devices it was clear that many man-hours are spent converting high-level floating-point simulations to suitable fixed point or integer formats. This conversion process requires, among other things, appropriate scaling to maintain the accuracy of calculations.

Often however, despite great care being taken in the conversion process, the speech quality obtained from the fixed point implementation is inferior to the high-level floating-point simulation because of round-off and truncation errors. Fixed point DSP implementations thus have the disadvantages of firstly requiring long conversion times and secondly yielding speech quality that is inferior to the original simulation. Mainly for these reasons a floating-point digital signal processing device, the WE DSP32[8], was chosen for the Skyphone codec implementation. This device is one of the most powerful and flexible floating point devices currently available. Some key features of this DSP are:

(*a*) 32 bit floating point arithmetic unit.
(*b*) Four 40 bit accumulators.
(*c*) 2 Kbyte of ROM and 4 Kbyte of RAM on chip.
(*d*) Off-chip memory expansion to 56 Kbyte.
(*e*) Serial and parallel input/output ports with DMA options.
(*f*) Instruction cycle time of 160 ns.

The WE DSP32 was favoured over other floating point DSP devices because it is well supported, is one of the more straightforward devices to use and because an upward-compatible CMOS device was soon to be introduced. Thus, although the first implementation of the Skyphone codec was on the NMOS part, the codec is now being implemented on the CMOS device (DSP32C) which has just become available. The CMOS part offers a full military specification, which is an important point when the aeronautical operating conditions, as outlined earlier, are considered. The lower power consumption of the CMOS part is also an important advantage in this application and, in fact, in any telecommunications application.

Speech Codec Hardware

The speech codec hardware is illustrated in Figure 8. The WE DSP32 microprocessor executes the speech coding algorithm and the remaining hardware elements provide the required analogue-to-digital/digital-to-analogue conversions and the appropriate timing signals.

At the encoder the timing derivation block generates all the required clock frequencies phased locked (when required) to an externally applied 9·6 kHz clock at the encoder. The clock frequencies generated are:

- an 8 kHz sampling rate clock
- a 50 Hz frame synchronisation signal
- a 1.2 kHz clock to the DSP32 controlling the digital input/output of the coded data
- a 1536 kHz serial input/output clock

The 8 kHz sampling rate clock is connected to the PCM codec device which samples the incoming speech signal and generates an 8 bit A-law encoded PCM sample every 125 μs. The 8 bit samples are clocked out serially from the codec output to the DSP32 serial digital input at a clock rate of 1536 kHz. An 8 kHz clock is also connected to the input load pin of the DSP32. Every active transition of the sampling rate clock initiates a serial input to the DSP32.

As the coded speech samples are transmitted in frames of 20 ms duration, the 50 Hz clock signal is used by the DSP32 for frame synchronisation. As soon as some encoded data has been derived for the current frame the DSP32 commences to output data by loading the output serial register one byte (8 bits) at a time. The 1·2 kHz clock (one eighth of the 9·6 kHz rate) is used as the load control for this output serial register. The serial data is clocked out of the DSP32 using the 1536 kHz clock. Once 8 bits

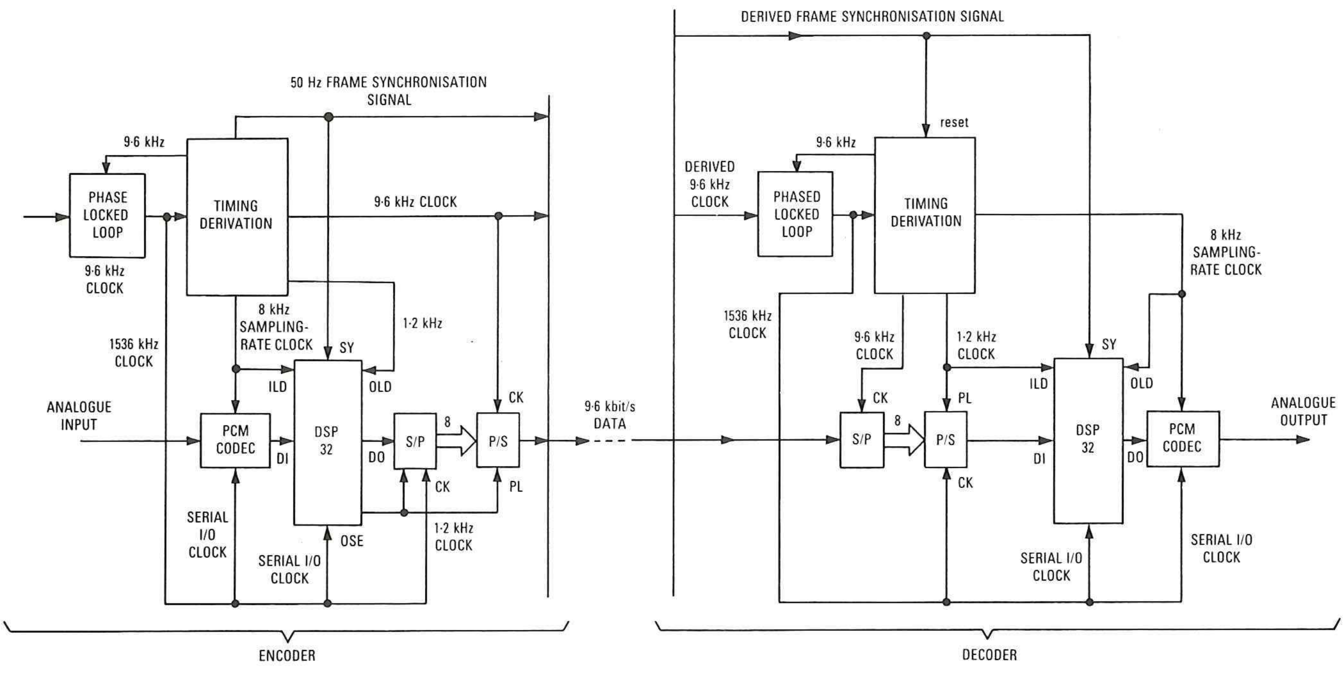


Figure 8
Speech codec hardware

have been clocked out, the output shift register empty signal becomes active. This signal controls the 8 bit serial-to-parallel and parallel-to-serial registers at the output of the DSP32, such that the burst of eight valid data bits at 1536 kHz is converted to a continuous data stream at 9·6 kbit/s. At the decoder a frame synchronisation signal and a 9·6 kHz clock signal are provided by the radio system. The interface to the speech decoder DSP32 essentially mirrors the encoder interface.

A photograph of a complete encoder/decoder is presented in Figure 9. The PWB photographed is populated with two DSP32s, program and data memory devices, a PCM codec and a logic cell array which implements all the random logic functions. It is now possible to implement a complete encoder/decoder on a single CMOS DSP32C, thus reducing this board area to half.

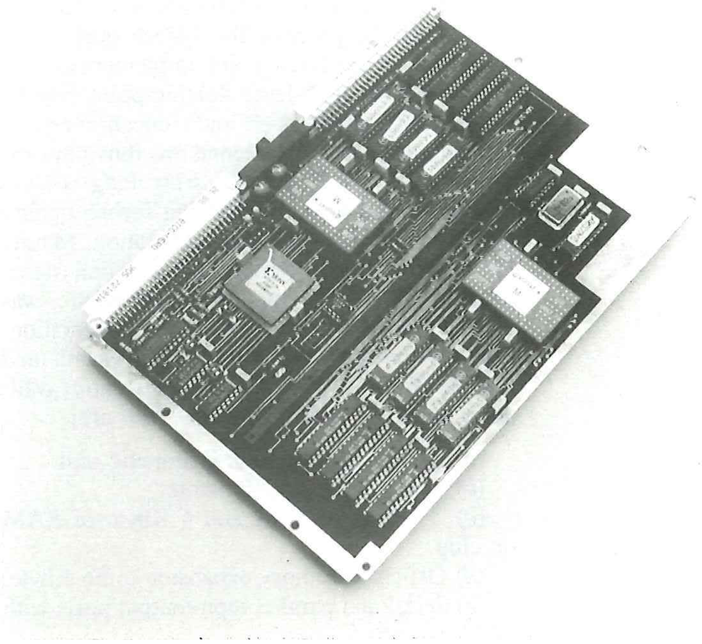


Figure 9
A complete encoder/decoder

TEST RESULTS

Subjective Test Results

An introduction to the rationale and the procedures adopted for the subjective testing of low bit-rate speech codecs is contained in reference 4.

Two sets of subjective tests have been carried out: the first tests were to select the speech codec for the BTI Skyphone trial service, and the second to select the speech codec to be the international standard for aeronautical communications.

Tests to Select the Speech Codec for the Skyphone Trial Service

As part of the procedure for selecting the codec for the Skyphone service, four codecs (one from Japan, one from the USA and two from the UK) were evaluated by a series of subjective tests[9]. The four codecs were designated A, B, C and D. Only codec D, the BTRL codec, is identified in the results. The subjective tests were designed to cover a range of input levels, listening levels and conditions representative of the operating environment of the Skyphone service. The procedure adopted for the listening tests was to assess each codec in isolation. To enable comparison to be made between different codecs, it was therefore necessary to include a transfer standard in each test. The standard used was the modulated noise reference unit (MNRU)[10], which provides a range of Q values in terms of signal-to-modulated-noise ratio. Not only can one codec be compared with another by establishing Q ratings, but each codec's contribution to total distortion can also be equated in terms of a known standard such as PCM.

The codecs were tested under the conditions shown in Table 1.

The speech material for the tests was taken from unconnected sentence recordings of male and female speakers. The aircraft noise recordings were produced and mixed at an analogue point with the speech recordings before being input to the codecs. The noise spectrum was representative of a typical Boeing 747 cabin with the level set 12 dB below the median speech level; that is, −30 dBV.

A block diagram of the test circuit is shown in Figure 10. A multi-path switch was used to route the various circuit conditions through the intermediate reference system (IRS)[11] to the subject. Although not shown on the diagram, the whole of the experiment was run by computer control; that is, switching of circuits, setting of attenuators, control of tape recorders and the storage of results. Periodically throughout the test a tone of 500 Hz was used to check levels at various points in the test circuitry. The computer also performed an analysis of variance and curve fitting functions on the results.

Separate tests were carried out with people being asked to vote on the speech quality or the listening effort required.

From the test results, the mean opinion score for different listening levels was derived for the various test conditions. The mean opinion scores for all four codecs with a median input level and no aircraft noise or errors (condition 2), and for a median input level with aircraft noise (condi-

TABLE 1
Codec Test Conditions

1. Codec	(High Input Level)
2. Codec	(Median Input Level)
3. Codec	(Low Input Level)
4 Codec + Aircraft Noise	(High Input Level)
5. Codec + Aircraft Noise	(Median Input Level)
6. Codec + Aircraft Noise	(Low Input Level)
7. Codec + Errors + Aircraft Noise	(Median Input Level)
8. Codec + Errors of 10^{-3}	(Median Input Level)

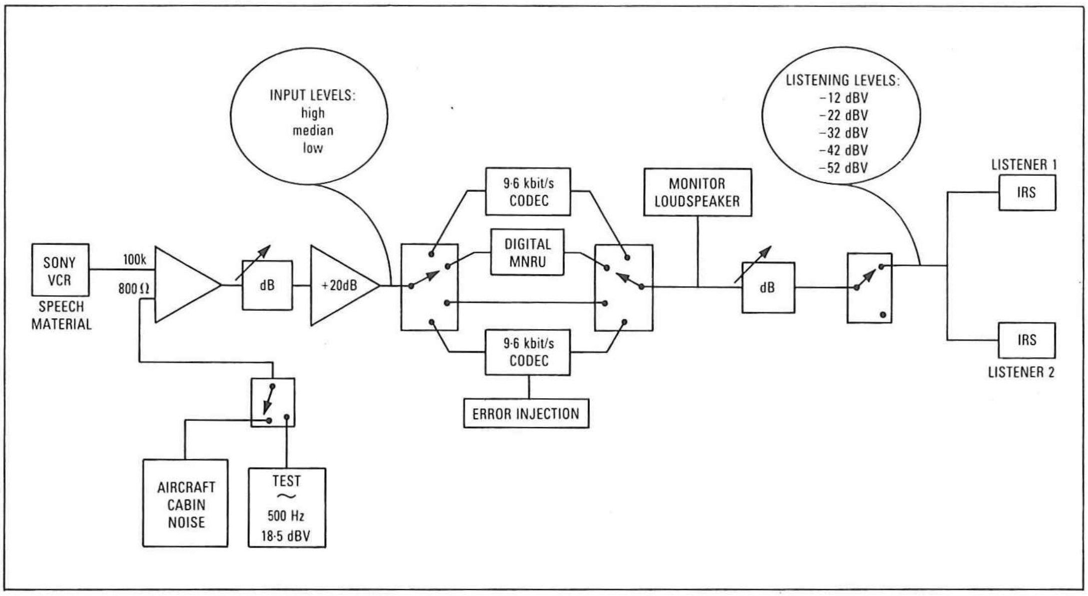


Figure 10
Test circuit for subjective tests

tion 5) are presented in Figure 11. The results for male and female speakers for each condition are presented separately. From these results it is clear that codec D, the codec from BTRL, yields the highest mean opinion scores for almost the entire range of listening levels. For all the codec test conditions, 1–8, the BTRL codec was similarly ranked higher than the other codecs for all listening levels except the very lowest (−60 dBV).

The Q ratings[4] for the BTRL codec (codec D) and the codec which was second best in the tests (codec A) for normal listening levels are shown in Table 2.

The subjective test report[9] gave a clear and definite recommendation that the BTRL codec was the most suitable codec for the Skyphone service in terms of speech quality.

Table 2
Codec Q Ratings (dB)

	Speech Quality		Listening Effort	
	Male	Female	Male	Female
BTRL Codec (D)	15·7	18·7	22·3	19·7
Second-best Codec (A)	9·5	11·9	8·9	14·2

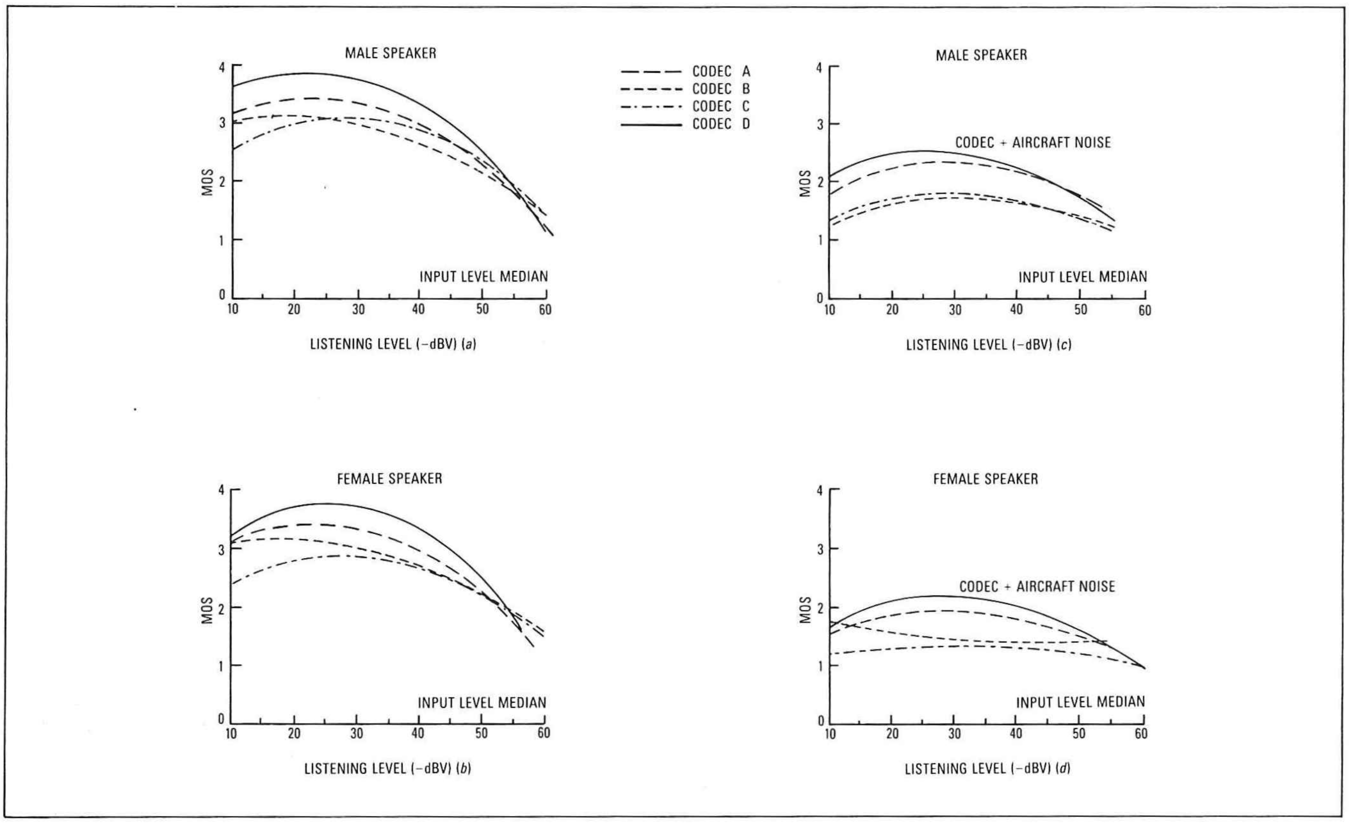


Figure 11—Subjective test results

Tests to Select the Speech Codec to be the International Standard

The Airlines Electronic Engineering Committee (AEEC), which is responsible for standardising all the communications equipment carried on commercial aircraft, was informed of the results of these subjective tests to select the speech codec for the BTI Skyphone service. This committee then commissioned its own tests to select a codec as an international standard. These tests were very similar to those described above but with the addition of conversation tests. Four codecs were selected by the AEEC for testing (two codecs from the USA, one from Japan and the BTRL codec).

Both English and Japanese were used in the subjective listening tests performed on the four selected codecs. Subjective test laboratories in the USA, Japan and England were used for the tests. The report on these subjective tests recommended that the AEEC adopt the BTRL speech codec for aeronautical satellite telephony, as it out-performed all the other codecs in the realistic operating conditions tested.

The conversational tests were performed by the UK Civil Aviation Authority (CAA). In these tests, air traffic controllers and pilots engaged in conversations similar to those which occur in air traffic control (ATC). Following these conversations, which were conducted through each of the four codecs under consideration, each air traffic controller was asked to compare the codecs. The UK CAA concluded from their test results that the BTRL speech codec was the most suitable codec for ATC.

The two reports on these subjective tests were presented to the AEEC's Voice Coding Working Group during December 1988. In the light of these results, the working group recommended that the BTRL codec be selected as the international standard for aeronautical mobile satellite telecommunications. This decision has since been ratified by the AEEC's Satellite Sub-committee which has submitted it for formal adoption at the next plenary session of the AEEC.

Test Results with Non-Speech Signals

The ability of the BTRL codec to pass dual-tone multi-frequency (DTMF) signalling tones has been investigated in a comprehensive set of tests[12]. The tests consisted of passing several tens of thousands of DTMF characters through a codec and analysing the received tones to ensure that the transmitted character was correctly received. The codec was tested with no bit errors, bit errors at 1 in 1000 and bit errors at 1 in 500 injected into the transmission path. The results are summarised in Table 3. From Table 3 it is clear that the BTRL codec passes DTMF tones very reliably, even at the nominal bit error rate of 1 in 1000.

These laboratory test results were confirmed during the Jetstream trials (see below) when numerous calls were successfully connected by DTMF dialling through the BTRL codec.

TABLE 3
DTMF Test Results

Error Condition	Percentage Characters Correctly Received
No errors	100·00
1 in 1000	99·78
1 in 500	99·36

JETSTREAM TRIALS AND TRIAL PUBLIC SERVICE

During May/June 1988, the Skyphone system was tested using a Racal Avionics executive jet. During the tests, many calls were made from the jet to those involved in the airlines industry (including air traffic controllers) in the UK and the USA. The unsolicited comments from those receiving the calls were that the voice quality was very good and that no appreciable difficulty was experienced in conversing over the link.

A trial commercial service was started in February 1989, providing two telephony channels to a British Airways 747 flying transatlantic routes. This service has proved popular with passengers and good usage is being made of it.

As this initial trial service does not provide a separate signalling channel for DTMF dialling, the DTMF tones are transmitted through the speech codec at call initiation. Transmission of these tones through the codec has proved to be very reliable. As most of the other speech codecs examined by BTI were not able to pass DTMF tones, the use of one of these other codecs would have required access to international operators to set up calls during the trial service.

CONCLUSIONS

The BTRL codec for the Skyphone service is a robust 9·6 kbit/s speech codec giving good speech quality. It is also capable of transmitting DTMF signalling tones. The codec is robust in terms of both background noise and transmission errors. Random transmission bit error rates of 1 in 1000 have no effect on speech quality and higher bit error rates of up to 1 in 100 have only a small effect. The effects of error bursts or breaks in transmission up to 20 ms are almost undetectable. The end-to-end codec delay is less than 40 ms with the codec requiring less than 75% of the available processing time on a WE DSP32. In a comprehensive set of subjective tests, the BTRL codec was ranked significantly better than the international competitors with which it was compared. It has been chosen as an international standard for aeronautical communications.

ACKNOWLEDGEMENTS

The authors would like to record their thanks to the other members of the group, C D Gostling, R M Mack and D K Freeman, all of whom worked very hard on the DSP software and hardware implementation.

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Biographies

Ivan Boyd received the B.Sc. in Electrical and Electronic Engineering from The Queen's University of Belfast in 1977 and continued his studies obtaining a Ph.D. from the same university in 1980. He continued in the Department of Electrical and Electronic Engineering as a research officer in the area of system identification. In 1983, he was appointed as a lecturer as part of the Government's information technology initiative. During his lectureship, his research interests included speech coding and electronic aids for the physically handicapped. In 1986, he joined the Speech and Language Processing Division of BTRL to research low-bit-rate speech coding and currently heads a group on low bit-rate coding.

Chris Southcott obtained an honours degree in Electrical and Electronic Engineering at Leeds University and joined BTRL in 1971 after working at the ITA Research Laboratories on colour TV transmission systems. He has worked on digital transmission systems employing both cable and optical fibre, and on low bit rate speech coding. He currently heads a section researching speech analysis, speech synthesis, speech and music coding.

Dennis Crowe joined BTRL in 1968, as a technician working on waveguide systems. He gained a 'minor award' to study at the University of Bath and in 1977 received a B.Sc. degree in Electrical and Electronic Engineering. After graduating, he rejoined BTRL and worked firstly on the assessment of transmission systems and then on the development of low bit-rate coding algorithms. This work led to the award of an M.Sc. from the University of Bath in 1986. He is currently working in a network modelling group, specialising in the development of quality assessment methods for new low-bit-rate codecs. He is also registered as a Ph.D. student with the University of Bristol. He is a Chartered engineer and a member of the IEE.

Peter Bolingbroke graduated from Southampton University with an honours degree in Electronic Engineering. In 1971, he joined the Space Systems Division of the then British Post Office, where he worked in a number of areas including the international regulation of satellite communications, the planning of broadcasting satellite systems, the European satellite system and the UNISAT satellite project. In 1984, he took up his present post in charge of systems engineering of British Telecom International's mobile satellite activities.

Quality—Experience with Department Purpose Analysis

F. J. REDMILL, R. I. KIMPTON, and M. ACOTT†

At a total-quality management workshop, it was decided to carry out department purpose analysis within a section of three groups. To gain experience, it was decided to carry out a pilot DPA in one of the groups. This article explains how the DPA was carried out, presents the experience gained and lessons learned, and assesses the results.

INTRODUCTION

It is recognised that, in most companies, between 15% and 45% of total effort is spent either unnecessarily or as the result of earlier poor quality. In most cases, the non-value-adding activities are not recognised as such, but are taken for granted as normal practice. Recognition of the situation, and improvement, result only from a change in company culture.

Like other parts of British Telecom, British Telecom International (BTI) has been running total quality management (TQM) workshops to introduce staff to the principles of total quality, induce them to use these principles in their work, and, thus, achieve a culture change in the company.

The essence of total quality may be summarised as:

(*a*) knowing what's to be done;
(*b*) knowing how to do it;
(*c*) doing it right first time; and
(*d*) knowing when it's done.

One total-quality tool, department purpose analysis (DPA), gets to the heart of the matter by addressing all four aspects. In May 1988, the management staff at Levels 4, 3, and 2 in the BTI Network Information Systems (NIS) section attended a TQM workshop and were asked to carry out a DPA within their section. As there was a need for data on carrying out a DPA in BT, it was agreed that the experience would be documented in a paper.

It was recognised that a well-conducted DPA would require the diversion of a significant amount of effort away from project work—and that without that effort there would be no point in the DPA. Moreover, with no available documented experience of DPA, early estimating was likely to be unreliable. It was therefore decided to carry out a pilot DPA in one of the groups, NIS3, prior to a full section DPA. This article reports the experience of the pilot DPA.

† Planning Directorate, British Telecom International

BACKGROUND INFORMATION

Department Purpose Analysis

DPA is a technique for ensuring that the activities of a department are designed to meet the goals of its parent organisation. If each part of a company streamlined its activities in this way, the whole company's goals could be met with a minimum of superfluous effort.

DPA recognises that every department has its customers and suppliers, even though, in many cases, these are within the department's company. For the department to be effective, its output should satisfy its customers' needs, in quality, quantity, and timing. Likewise, for the department to function efficiently, its needs should be satisfied similarly by its suppliers. Thus, a significant aspect of DPA is customer and supplier analysis.

DPA involves a study of the entire department, comparing the department's declared goals with the actual direction of the department's effort. A team within the department is set up to carry out the DPA, which is a 5-step process.

Step 1: Statement of Key Activities and Key Skills

This is a short step. The key activities in the department's work are listed. These are sometimes referred to as the *top ten* activities, but the list need not contain exactly ten items. The key skills needed to carry out activities are also listed.

Step 2: Purpose and Goals

The department's own direction, activities, and priorities are compared with those of the parent organisation (which implies that, by this stage, the parent organisation's mission, activities, and priorities should have been agreed and documented). The parent organisation's manager must agree that a match exists.

Step 3: Customer and Supplier Review

All the department's customers and suppliers are identified. Interviews are then arranged and carried out with each, to identify and agree requirements, performance and quality standards, and methods of measurement.

Step 4: Time and Skills Analysis

All staff in the department record their activities and the time spent on each, every day for a chosen period. An analysis is then carried out to determine how the department's effort was spent, and what skills were used. The activities which contribute directly to meeting customers' requirements are identified. Likewise, those which do not contribute to meeting customers' requirements and those which result from failure are identified. Ways of eliminating these latter two categories of activities are sought.

Step 5: Action Plan

Projects are set up to eliminate the non-value-adding activities. Targets are set, teams are set up, improvement-measurement methods are decided on, the projects are launched, and progress is monitored.

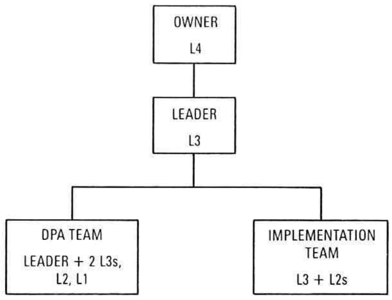
The Department

The Network Information Systems (NIS) section consists of 53 staff in 3 groups, and develops computer systems for applications in support of the international telephone network. Each group is engaged in two or more development projects at any time, and projects range from very small (1 man-year or less) to very large (tens of man-years). When projects are completed and the computer systems installed, the section is responsible for their software and system maintenance. NIS3, the department on which the DPA was carried out, is a group of 17 staff.

Previous initiatives over a number of years had instilled a quality awareness and introduced, for example, formal project management[1], document quality control and assurance[2, 3], and software-development and testing standards. In addition, staff were in the habit of recording their time spent on project activities, such records being used for calculating project costs and reviewing earlier project estimates. With this background and culture, the staff recognised the potential benefits of DPA, and they were both in a position to use it well and keen to do so.

ORGANISATION FOR THE DPA

In defining the responsibilities of all parties involved in the DPA, a four-tier structure (see Figure 1) was established. This may at first seem excessive, but the reasons are given in the following paragraphs.



Note: L4 Refers to Level 4 manager, etc.

Figure 1—Pilot DPA organisation

The Owner

Although the DPA was carried out within a single group, the Head of Section needed to be involved. He needed to ensure that the pilot was completed on time so that the Section DPA could proceed according to plan. He also had to co-ordinate the lessons and experiences gained from the pilot DPA and ensure that they were applied to the Section DPA. He was therefore designated the 'owner', and he assumed the responsibility of monitoring progress against plans and making sure that regular reporting took place.

The Leader

The head of the group being analysed was made responsible for planning, carrying out, and reporting on the DPA. Specifically, his responsibilities were

- to manage the DPA Team,
- to manage the Implementation Team,
- to chair the progress meetings,
- to report to the owner, and
- to ensure that the DPA was documented.

The DPA Team

The first constituents of the team were the leader and the heads of the other two groups in the section. These two Heads of Group sat on the team to observe and, when appropriate, to advise. The leader added to the team one Level 2 and one Level 1 manager from the group, first, to achieve communication about the DPA throughout the group, and, second, to involve them in the planning and administration. The DPA Team was responsible for planning the DPA, briefing the group and others of progress, and analysing the results of the DPA activities received from the Implementation Team.

The Implementation Team

This team consisted of the Head of Group and all Level 2 managers in the group. Its role was to undertake the DPA activities, in accordance with the DPA plans, and to involve all staff in the group as far as possible. It passed the results of the DPA activities to the DPA Team.

PLANNING AND CONTROL

A prerequisite to the DPA is the completion of Steps 1 and 2 at management and organisational levels above the 'department' being analysed. It is only possible to determine with certainty a department's direction, priorities, and key activities when these can be seen not to be contrary to those of the parent organisation. This emphasises that total quality must be top-down within an organisation.

It had also been recognised from previous NIS development projects that sound planning led to better project control, and the decision was taken to employ the tools and methods previously used with success. As the group had experience in controlling projects using PROMPT II, a project-management tool[1], it was decided to use the principles of PROMPT II for controlling the DPA. The DPA was treated as a project: plans were prepared, tasks were defined and delegated, and regular reports were made against the plans. In addition, techniques such as brainstorming and consensus reaching were used to gather and select data.

CONDUCTING THE DPA

Step 0

This step was created for planning the DPA and performing preliminary functions, such as ensuring that the section's vision, mission, key activities, and key skills were documented and agreed by higher management.

Detailed plans were drawn up for the DPA. The main functions of each step were subdivided into tasks, and estimates of the effort required were made. Carrying out these activities facilitated good communication within the group of what was going on, and it allowed staff to know in advance what would be expected of them. It also facilitated reporting and control of the DPA activities.

Step 1

The DPA Team listed the group's activities, and those that were 'key' were singled out. This exercise proved to be straightforward, although it was later recognised that some of the identified key activities were, in fact, subordinate to those which were seen to be 'value-adding' by the customers and suppliers. This emphasised the fact that the perspective of the owner, responsible for managing a **project**, is not the same as that of a customer, who is interested only in a **product**.

Step 2

Because of impending organisational changes at the time of the pilot DPA, it was difficult to define the group's long-term vision. However, it was achieved by taking a 'snap-shot' approach, and a vision of the group three years into the future was agreed with the owner. The group's mission, key activities, and skills were certified by the owner as aligning with and contributing to the section's mission.

The process of defining and agreeing the mission and vision made the group members feel more sure of their purpose and more involved with their own destiny.

Step 3

This step proved to be the most beneficial, because the group had not previously had this type of working agreement with their customers or suppliers, although formal project documents (for example, System Requirements Specifications), produced to documented standards, were normal aspects of project work. Some methods of monitoring the group's own performance existed (for example, the number of requests for change to developed computer systems, and the results of Fagan's Inspection[2, 3]), but the act of preparing for the interviews focused the mind on areas for improvement in the group's methods of measuring performance. As a result of the interviews, formal agreements (see Figure 2) were drawn up and these have formed the basis of the group's customer-supplier 'information base'. This information base is a part of the NIS3 Total Quality System.

Because of the large number of interfaces between the group and its customers and suppliers, there was some difficulty in finding time for all possible interviews during the pilot DPA. This was resolved by limiting the interviews to those customers and suppliers who were known to be directly associated with the key activities, and whose relationships with the group were likely to continue. Other interviews were postponed until the section DPA. This was permissiable because the purpose of the pilot was to gain experience prior to undertaking the section DPA.

The purpose of the interviews with the customers was to establish an agreed working relationship by specifying:

- the customers' requirements;
- the group's current performance, as perceived by the customer, in meeting those requirements;
- how the customers measure the group's performance;
- how the group measures its own performance; and
- what can be done to improve the group's performance.

The purpose of the interviews with the suppliers was to establish an agreed working relationship by specifying:

- the group's requirements;
- the suppliers' working methods for meeting the group's requirements;
- how suppliers measure their own performance;
- the group's methods of measuring the suppliers' performance; and
- what can be done to improve the suppliers' performance.

NIS INTERFACE AGREEMENT

CUSTOMER INTERVIEW

1. Introduction

An interview was held between ______________ of NIS (the Supplier) and ______________ (the Customer) to establish:

—the customer's requirements of NIS;

—NIS's performance in meeting those requirements and how NIS measures its own performance;

—how the customer measures NIS's performance;

—what can be done to improve NIS's peformance.

This document records the agreements reached between NIS and the customer on the above topics.

2. Customer's requirements of NIS

It was agreed that NIS should provide:

3. NIS's method of measuring its own performance in meeting the customer's requirements

It was agreed that NIS's measurement of its own performance was by:

4. The customer's method of measuring the performance of NIS:

It was agreed that the customer measures NIS performance by:

5. What can be done to improve the performance of NIS

It was agreed that NIS's performance would be improved by:

Customer's Name:		Duty:	
Customer's signature:		Date:	
Supplier's Name:		Duty:	
Supplier's signature:		Date:	

Figure 2—Basis of agreement with customers

It was essential for all staff conducting interviews to be well versed in the group's mission and vision, and to have an understanding of the group's requirements. It was also necessary for them to achieve the purpose of the interviews. As an aid, interview packs were produced. These contained guidance to the interviewer, an agreement sheet (see Figure 2) to be signed by both interviewer and interviewee, and information sheets to be sent in advance to interviewees, explaining DPA, its purpose, and what needed to be achieved at the interview. These latter proved particularly useful, as they enabled interviewees to be prepared for the interviews.

Interviews were conducted at all levels within the group. There was an unfounded fear that an agreement reached by lower management might be unacceptable to higher management. In all cases, the results of interviews were agreed by higher management as correct at the time of the interview. However, it was recognised that the agreements were liable to change as responsibilities changed, and would therefore require regular review.

As expected, there were occasional difficulties in arranging interviews. In planning a DPA, it is as well to allow ample notice to interviewees, and to let them know the timescale being adhered to. Interviewees external to the company may also be a problem. While it should not be difficult to obtain interviews and verbal agreements, signed agreements may have to be processed by their legal or contracts department (and BT's).

Step 4

The majority of the group's work is project-based, with an average project life cycle of two years. The project life cycle consists of six stages which form six of the key activities. To record the time spent on each activity, it would be necessary to sample the allocation of time for a period of about a year. Because of the need to complete the DPA within a limited time, it was decided to record the time spent on each activity for a two-week period. However, it was realised that some of the group's key activities would not be performed during that time.

It was also recognised that, unless the bulk of each individual's time could be allocated to pre-defined activities, the analysis of time records would be unmanageable. However, the risk of using pre-defined activities was that failure may be erroneously allocated to one of the categories rather than be separately recorded. However, with a quality culture existing in the group, it was felt that the level of discernment was high and the risk of incorrect recording low. The key activities identified in Steps 1 and 2 were, therefore, broken down into sub-activities. Other, non-key, activities were then identified and included. All group members were then requested to record their time spent on each activity on the resulting list, and to identify and record any other activities performed. Daily totals were recorded against each activity, to the nearest 15 minutes.

The results were summed on a Level 2 sub-group basis, and analysed by the DPA Team. Each key activity was assigned to one of four categories—Basic, Prevention, Appraisal, or Failure—and the results are shown in Table 1. The non-key activities were not separated into the four categories. They were summed under the heading 'unassigned', and are seen from Table 1 to have occupied 36% of the group's time during the DPA.

TABLE 1
Categories of Time Allocation

Activity	% of Total (Manhours)
Basic	46
Prevention	0
Appraisal	8
Failure	10
Unassigned	36

With hindsight, it was apparent that time analysis would have been greatly simplified had the recording system made provision for recording failure against each activity rather than as a separate class. This principle was to be adopted in the section DPA.

It appears from Table 1 that zero time was spent on prevention. However, first, the study covered a two-week period which happened not to include any dedicated prevention activities, and, second, many activities classified as 'basic' contain an element of prevention. This result led to a re-definition of the categories for the section DPA.

Step 5

An assessment of the first four steps was carried out, opportunities for improvement sought, and improvement projects set up. As it is the purpose of this paper to describe the DPA process, and the improvement projects are specific to the department being analysed, they will not be discussed here. However, it is important to note that the planning, implementation, and measurement of improvements are not confined to this step, or, indeed, to DPA, but may be performed at any time.

IMMEDIATE GAINS FROM THE DPA

Irrespective of improvement projects that were set up, the DPA yielded certain gains which may be of general interest to readers.

Activities

Identification of the group's non-key, as well as key, activities led to the recognition of non-value-adding tasks on which time was being spent. As a result, improvement projects have been instigated to minimise the time spent on these tasks.

Customer–Supplier Agreements

Although a difficult task, it was found to be beneficial to both the customers and suppliers that all requirements and means of measurement were documented and agreed. This should ensure that there are no ambiguities over responsibilities and that the requirements of the customer and the business are fully met. In particular, interviewers became aware of requirements which customers had known of for some time but which had not yet been stated. These were immediately dealt with via the proper channels. In this way, the DPA acted as a catalyst for identifying and resolving existing problems.

Further, it was recognised that, by performing interviews with customers and suppliers at the commencement of any new project or after organisational changes, the requirements of the group and its customers, and the means of measuring performance, would always be fully documented and agreed.

Skills to Perform Key Activities

Identifying the skills required to perform each of the key activities led to a more formal approach to the group's training needs. Job-specific training schedules and a skills record for each individual have been produced. The gains from allocating appropriately-skilled individuals to the key activities were also highlighted.

LESSONS IN THE DPA PROCESS

Prerequisites

It is essential that Steps 1 and 2 have been performed at the management level above the department which is to perform the DPA. If this has not been done, the context within which the department must work is undefined, and there is no measure of effectiveness of the department's efforts. A DPA would then be premature.

Customer–Supplier Interviews

The selection of customers and suppliers for interview needs careful planning and organisation. Although some customers or suppliers may have dealings, on different subjects, with different parts of the department, co-ordination should be maintained so that only in exceptional circumstances is a customer or supplier asked to attend more than one interview. Criteria for selecting interviewees should be defined so as to limit the interviews to a manageable number.

The interviews should be carried out throughout the department, but a top-down approach is strongly recommended. In this way, agreements reached by higher-level managers act as a foundation for subsequent agreements at lower levels, thus minimising the possibility of conflict. This process, however, demands time for planning the interviews and documenting and circulating the agreements.

It should be noted that improvement is not limited to the department performing the DPA. Better understanding of a customer's or supplier's working methods by an interviewee may lead to changes (improvements) in the interviewee's own department.

Preparing Interviewees

Interviewees should not be assumed to have heard either of DPA or of customer–supplier agreements. If interviews are to be efficiently conducted and successful, interviewees must be given ample notice of the interview, advised of its purpose, apprised of DPA, and offered the opportunity to have their questions answered. In the pilot DPA, the first three items above were achieved by sending a standard information sheet to interviewees at the time of arranging interviews.

Staff Involvement

Because DPA is a tool for aiding the implementation of total quality, it is sensible to involve as many staff as possible. This was achieved in the pilot DPA by appointing all Level 2 managers in the group to an Implementation Team, and by the involvement of all their staff in all possible DPA activities.

Time Analysis

It was beneficial to use pre-assigned activities for the time analysis. It is recommended that, when this is done, the list contains all activities in which the department could be involved, and that the form includes a section for the description of unlisted activities which are performed. Moreover, to aid later analysis, the activities should be defined in sufficient detail for each to be unambiguously classified into one of the three categories: basic, prevention, and appraisal. The time sheet given to staff should then have space against each activity for both successful work and failure. In this way the analysis work for the DPA Team is kept to a minimum, costs of failure are identified, and improvement opportunities are more easily identified.

Skills Analysis

It was found that the DPA section of the Tools and Techniques Handbook lacked detailed skills analysis techniques and guidance on how the list of key skills should be used. The DPA Team

proposed the procedure shown below, and this has now been accepted and approved by the BTI Quality Services.

'During Step 1, identify the skills required to perform the key activities.

'During Step 4, record the key skills of each member of the department. Identify and record those key skills actually used to perform an activity and those skills that are required to perform the activity effectively but were not available.'

The Step 4 activities thus check the key skills identified in Step 1 and highlight any skills overlooked. This information can then form a database of key skills available and required for the various activities. From this database, the manager is able to control manpower more effectively by choosing the 'right person for the job'. Where the appropriate skills are not available, the manager is able to instigate relevant training or plan the recruitment of staff with the appropriate skills.

EFFORT TO PERFORM DPA

At the outset, there was confidence in the group that DPA would be a beneficial and interesting exercise. A study was made of the various steps, and an estimate of 60 man-days was made for carrying out the DPA (with the exception of Step 5). In the event, there was an actual requirement of 65·5 man-days (see Table 2).

Of the 65·5 man-days, about 50% represented the detailed planning and administration performed by one member of the DPA Team. The familiarity and expertise gained by this individual, through having a permanent and defined responsibility for the day-to-day planning and over-sight of the DPA, resulted in smooth continuity and effective control of the exercise.

Recent reports, from other DPAs now in progress, are of figures higher than those in Table 2. It is suggested that the use of project-management tools and techniques, the experience of planning and working to plans, the disciplined nature of software engineering, and an existing quality culture all contributed to an efficiently-run DPA.

COST/BENEFIT ANALYSIS

A number of improvement projects have been initiated within the group as a result of the DPA. However, at the time of writing, it is too soon for improvements to be measured.

One important project is to improve communication within the group. The proposed means of measurement relates to internal communication, but the spin-off is expected to be better lower-level decision making due to a broader perspective. This would result in increased efficiency in all of the group's work.

The total effort put into the pilot DPA equates to about 2% of the group's annual manpower.

TABLE 2
Effort in Man-days to Carry Out the DPA

	Step 0	Step 1	Step 2	Step 3	Step 4	Step 5	Total
Planned	6	6	2	32	14	N/A	60
Actual	5	1·5	4	41	14	N/A	65·50

If the time spent on non-key activities were reduced from 36% to 30%, there would be a pay-back period of 4 months (the duration of the DPA) for the DPA. A project to reduce the effort spent on non-key activities consists of

(*a*) a more-detailed analysis of the effort spent on the non-key activities,

(*b*) identification of what could be eliminated (for example, ineffective meetings, quality costs related to services provided elsewhere in the company), and

(*c*) planning a course of action for improvement.

Actual failure costs identified during the DPA were 10%, of which 4% was attributable to support work on systems already in service and 6% to rework during system testing. Both these figures are good by generally-accepted industry standards. A quality improvement project was not set up to improve the 6% rework, because normal procedures include an analysis of this in the post-project review of each project. This provides feedback to improve future work and exactly parallels the quality-improvement process.

CONCLUSIONS

This article has described a department purpose analysis carried out in NIS3, a group in the Network Information Systems section in BTI. The DPA was treated as a project. Formal plans were produced, the DPA was controlled against these plans, and the effort expended was carefully monitored.

In using project-management procedures and techniques, a number of innovations were introduced into conducting a DPA. These have been described in the article. The lessons learned have been presented as a guide to others embarking on a DPA. Although the improvement projects resulting from the DPA are not yet completed and the benefits have yet to be measured, it is already clear that the DPA was worthwhile. Not only have the group members gained from the experience, but also it was shown that relatively-minor cost-saving improvements would result in a payback period comparable with the duration of the DPA.

However, a DPA requires a significant diversion of manpower from other tasks. Unless this diversion is wholly committed and the process well managed, the results of the DPA are likely to be misleading. Yet, importantly, the DPA

highlights the fact that many of its activities (for example, making formal customer-supplier agreements, and seeking opportunities for quality-improvement projects) need not await a DPA. They should be the standard form of working.

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Biographies

Felix Redmill has worked in a number of fields within BT, including programming and systems analysis, teletraffic engineering, stored-program control, and exchange maintenance. He is currently Network Information Systems Manager in BTI, and is responsible for a software-engineering section in which high standards and quality are of the greatest importance. He is a Chartered Engineer.

Robert Kimpton is head of a Network Information Systems group in BTI. He has recently lead the section's pilot department purpose analysis, performed in his group. He has been responsible for the development of a number of information systems to support the operation, maintenance and management of the international telephone network. He has a master's degree in Telecommunications Systems and is a Chartered Engineer. Prior to his present position he has worked on telecommunications strategy, stored-program controlled Telex, and speech-band data transmission.

Mike Acott is a Level 2 in BTI's Network Information Systems section and is responsible for the software maintenance of computer systems which support the international telephone network and BTI's international exchanges. He was responsible for much of the planning and administration of the DPA described in this paper. He has an Open University honours degree.

Microwave Radio in the British Telecom Access Network

F. G. HARRISON†

This article describes new developments and new applications of microwave radio systems in the British Telecom access network. Working from the background of predominantly trunk use of microwave radio, the assets of radio pertinent to the junction and local networks are highlighted. The article recognises that, for radio to enjoy general application in the access network, it must be both easy to use and cost effective compared to cable solutions. An example where both of these conditions are satisfied is the growing use of 18 GHz radio for MegaStream customer links. The article then looks at other potential applications of this type of point-to-point link, revealing possibilities in the junction network for closing transmission rings and/or alternative routing, and as a local loop relief system.

The possible use of multipoint radio systems in the local loop is examined and an overview of British Telecom's current technical and economic studies on the use of these systems is presented. Although presently-available multipoint systems are not likely to find general use in local network modernisation, the potential use as a rural overlay is exposed, and a design brief for an 'ideal' radio distribution system is discussed.

The conclusions are that the technical and economic barriers to the use of radio in the access network are being eroded and that future penetration of radio into the junction and local networks can be predicted with confidence.

BACKGROUND OF TRUNK RADIO SYSTEMS

To date, the main application of microwave radio systems in the British Telecom network has been for long-haul high-capacity transmission. The construction of an extensive analogue radio network in the 1950s and 1960s for television and telephony transmission has been well reported[1]. The first digital radio systems were introduced into the UK trunk network in 1982, these being 140 Mbit/s 11 GHz systems using QPSK modulation. Since then, a variety of different digital radio systems has been installed for trunk transmission in the 2, 4, L6 and U6 GHz bands. In general, radio has proved cost effective compared to cable systems on long-haul routes and for routes involving difficult terrain or over-water paths. Furthermore, radio offers both alternative routing and alternative technology to cable systems, thus providing greater network security. These factors have given radio an important role in the trunk network where there are now about 200 radio stations carrying approximately 20% of the total trunk traffic.

World-wide, a general increase in traffic demand, coupled with a drive for more efficient use of the radio-frequency spectrum, has resulted in the development of radio systems of increasing complexity. Modern systems typically employ higher-order modulation methods such as 16QAM and 64QAM and include diversity, adaptive equalisation and error correction techniques. The planning, installation and maintenance of radio links to achieve the required performance under anomalous propagation conditions requires specialist expertise. Over the years, the British Telecom organisation and infrastructure associated with radio has evolved in line with both the requirements and the technology of trunk applications. Specifically, the planning, procurement, installation and operation of radio systems in British Telecom is carried out by Head Office and regional staff, with little involvement of local District Offices. This has resulted in radio being somewhat inaccessible at local level, where it is often seen as something of a 'black art'. Consequently, to date, there has been little use of radio outside of its traditional trunk role.

JUNCTION AND LOCAL LOOP APPLICATIONS

As the focus of modernisation in British Telecom moves to the junction and local loop, a new opportunity for radio systems is emerging. In the past, cable systems have been used in these areas almost exclusively, with very little penetration of radio. However, radio can provide specific benefits and form a complementary

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technology to cable in the junction network and local loop. In particular, the assets of radio are:

- fast provision,
- flexible for reconfiguration of network topology,
- easily recovered and re-used,
- cost effective on routes where duct does not exist,
- provides quality improvement on problematic cable routes, and
- provides an alternative technology and routing for network security

Although radio technology has offered these benefits for some time, two particular barriers need to be overcome before radio can find general use in British Telecom Districts. Firstly, radio systems must be simple to plan, install and maintain, such that District staff who are not radio experts can be confident in their deployment. Secondly, equipment cost reductions are important if radio is to compete with cable on shorter routes. These barriers are now being overcome with new technology, and this article describes current and potential applications of point-to-point and multipoint radio systems in the British Telecom junction and local network.

POINT-TO-POINT RADIO SYSTEMS

MegaStream Customer Links

British Telecom has been using 18 GHz point-to-point radio links operating at 2 and 8 Mbit/s for several years. Early versions of the radio equipment were large, cumbersome and expensive: as a result, the application of radio was limited to particularly problematic routes. An example is described in reference 2. New modern designs of 18 GHz radio equipment became available in 1985/6, concurrently with a rise in demand for MegaStream private circuits and it was recognised that radio would be an important competitive tool in providing fast service to customer sites. New radio equipment was purchased which was ideally suited to access network applications as described in reference 3. Each radio terminal comprises an indoor-mounted unit providing traffic/customer interfaces and an external radio cabinet and antenna. Coaxial cable links the indoor unit to outdoor unit which can be mounted on a pole together with the antenna. Parabolic antennas of 0·3, 0·6 or 1·2 m diameter are used depending on the hop length. A typical outdoor installation is shown in Figure 1.

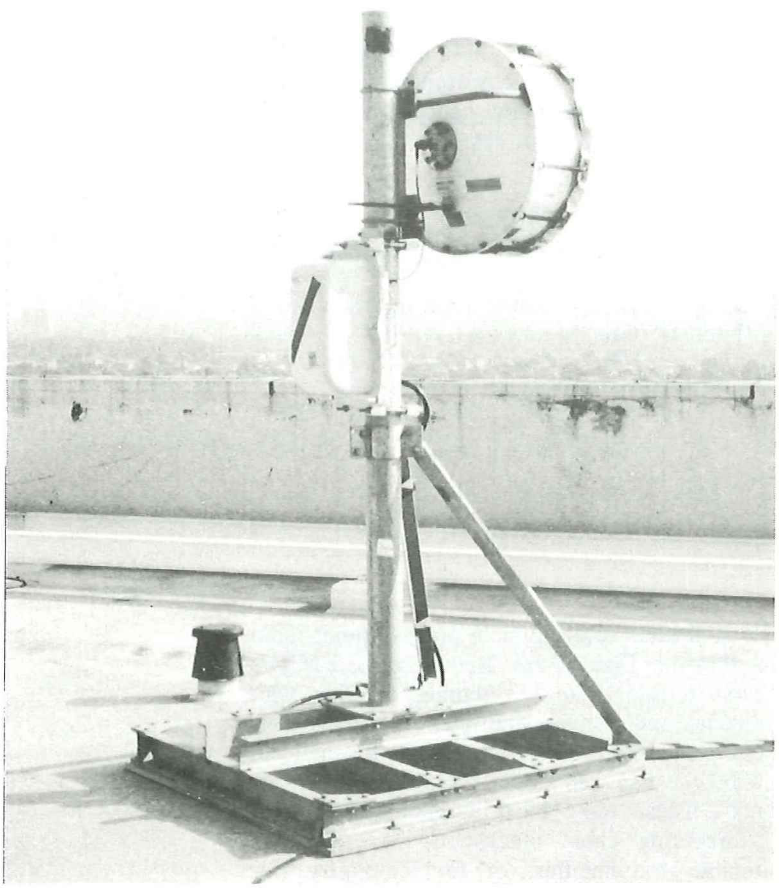


Figure 1 Typical 18 GHz radio roof-top installation

A number of design features of the 18 GHz radio have been important in gaining acceptance of radio technology in Districts and the more important of these are described below:

High performance—simple planning Typically, links average at about 10 km, with the longest hops at 20 km. A high system gain is offered by the equipment which means that small antennas can be used and longer waveguide feeder runs can be tolerated. Planning of links is relatively simple, although frequency co-ordination with other links and a line-of-sight path to the distant terminal are, of course, still required. Links are planned using simple line gain/loss budgeting by using a fade margin/distance curve as shown in Figure 2, which allows for rainfall-

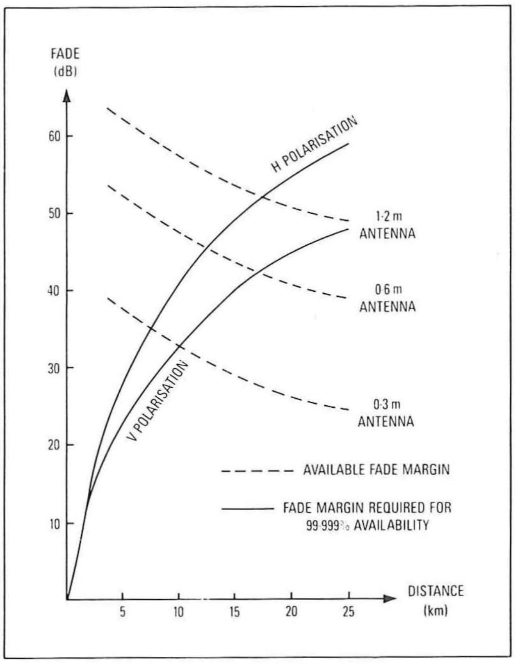


Figure 2—Fade margin/distance curves for 18 GHz 8 Mbit/s radio links

induced outage and which gives high link performance and availabilities exceeding 99·999%.

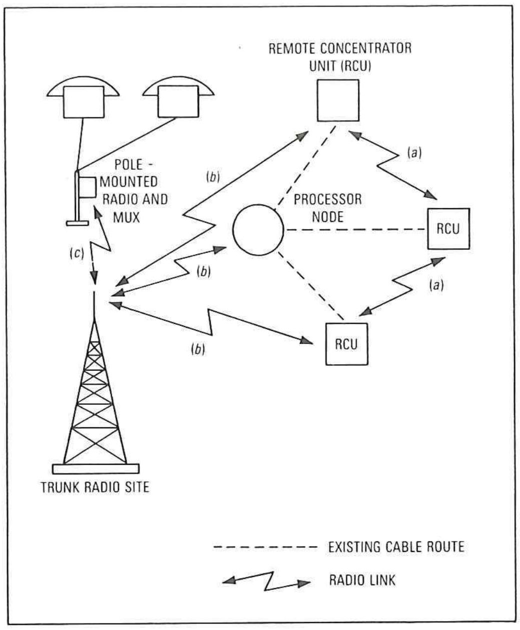
Simple installation and maintenance The construction is important, and the equipment and antennas are compact which reduces the cost of transportation and simplifies installation. Maintenance of external equipment has always presented a problem, particularly where roof or tower access is required, which demands the use of suitably trained staff and rigorous safety practices. Longer waveguide runs now enable around 75% of radio cabinets to be mounted indoors where access is easier. Maintenance of faulty units is by simple replacement of a complete unit and does not demand particular radio expertise.

High reliability The new 18 GHz radio has high reliability with links now being operated on an unprotected basis and requiring little or no maintenance attention. Previously, 1+1 configurations were seen as essential, with obvious cost penalties.

Cost considerations have also been important in determining the volume of applications for customer link radio. The new radio technology has resulted in significant cost reductions such that, currently, the capital cost of an 8 Mbit/s radio link is equivalent to the cost of providing a few hundred metres of new duct. This has meant that, where duct is not available, radio is cost effective and this has been reflected in a dramatic increase in the use of 18 GHz radio by British Telecom. To date, several hundred customer links have been provided over radio and the potential for using point-to-point radio in other network applications is now being recognised.

Evolving Applications for Point-to-Point Links

A general restructuring of the British Telecom network is underway, to provide digital processing at a small number of key node sites and serving large catchment areas directly and via remote concentrators (RCUs). The junction network transmission systems will be arranged in ring type structures, providing alternative routing and security. The existing traditional tree-and-branch network structure therefore requires interlinking transmission routes between branches in order to complete the rings. While many of these links can be provided by existing inter-exchange cable routes, where there are gaps, radio can be used as shown in Figure 3 (*a*). Radio can be particularly cost effective compared to new ductwork. Another way in which radio can be used to provide alternative routing is by using the existing trunk radio towers as distribution points to provide transmission coverage over a wide area. This is shown in Figure 3 (*b*). The tower is linked to the nearest node by radio or cable and point-to-point radio systems are used to reach isolated RCUs. Such an arrangement can also provide temporary or emergency links at short notice.



(*a*) Closing rings
(*b*) Alternative routing
(*c*) Local loop relief

Figure 3
Applications of point-to-point radio

However, for radio to be competitive with fibre transmission, which offers simple capacity upgrades, it is important that radio links can also cater for traffic growth, without complete link re-engineering. A family of 2, 8, 34 and 140 Mbit/s 18 GHz radio systems can achieve this as shown in Table 1. All these systems can be installed as simple roof-top installations, and offer many of the attributes previously described for the 8 Mbit/s radio systems. British Telecom is also looking at the future use of 18 GHz radio systems providing 155 Mbit/s STM-1 transmission as part of the synchronous digital hierarchy, although space does not permit this article to discuss this work in detail.

TABLE 1
Family of 18 GHz Radio Systems

Capacity (Mbit/s)	System Gain (dB)	Antenna size (m) for hop of			
		10 km	15 km	20 km	25 km
2	109	0·3	0·6	0·6	1·2
8	109	0·3	0·6	0·6	1·2
34	98	0·6	0·6	1·2	1·2
140	96	0·6	1·2	1·2	—

A further application of point-to-point radio is shown in Figure 3 (*c*). Here a simple 2 Mbit/s radio terminal can be mounted together with antenna and primary multiplex on a pole. This can then provide 30 speech circuits for the local network, parented directly onto the processor node. These 'radio' local lines could be used for overcoming cable blackspots, for accessing remote communities, or for temporary (for

example, county fair) requirements. The radio link could be provided by 18 GHz systems using small dishes for distances of up to 20 km or 2 GHz systems employing Yagi antennas for longer distances or marginal radio paths.

There is, therefore, a range of potential applications for point-to-point radio in the junction and local network using new generation radio equipment that is compact, cost effective and simple to install and operate.

POINT-TO-MULTIPOINT SYSTEMS

In addition to the conventional point-to-point radio systems, digital point-to-multipoint radio systems, as reported by the CCIR [4, 5], are now becoming available. These typically comprise a central station serving many outstations via radio links and time division multiple access (TDMA) techniques. Customer circuits are provided between outstation and central station on either a fixed assignment or a demand assignment basis. These multipoint systems offer the general benefits of radio as described earlier (fast provision, flexibility, etc.) and are suited to providing low-capacity transmission links distributed over a wide area. British Telecom has been conducting studies of such systems for both urban and rural local access applications.

Urban Overlay

Modernisation of the cable access network to provide data or ISDN services can be problematic owing to two factors. The existing wire circuits were not designed to provide data transmission which means that it can be expensive and time consuming to upgrade the cable performance. There are also limitations on achievable loop length. Multipoint radio can be used as an overlay to solve particular local cable troublespots, and data and ISDN services can be extended over much greater distances than possible with unrepeatered metallic cable. Radio can also be provided rapidly and the system can be extended or reconfigured quickly to meet changing or unforeseen demands. In 1987, a trial of a 18 GHz multipoint system was commenced in Glasgow. The system provides a short-haul city overlay and makes data circuits available from 12·6 kbit/s to 152 kbit/s on a fixed assignment basis for private circuit provision. Reference 6 gives details of the system which uses roof-top-mounted outstation equipment. The Glasgow trial has shown that multipoint radio is practicable for use in a District and that high performance standards can be met.

However, in the urban environment, providing fibre into major customer sites has become attractive and offers particularly flexible service provision. Furthermore, multipoint systems are relatively expensive compared to cabling in a short-haul urban environment and these factors have resulted in a limited scope for urban multipoint systems.

Rural Modernisation

The rural local network is characterised by small rural exchanges and an associated local access network which has significant amounts of overhead cable for connections to dispersed and remote customers. Rural areas cause specific operational difficulties in having high cost of provision and maintenance, low revenue, and sometimes poor quality of service due to unreliable overhead distribution. Current digital switching and optical transmission systems, although economic for trunk and junction applications, are not as easy to justify economically in the rural local network.

Multipoint radio provides an opportunity for complete replacement of all or part of the rural local network as shown in Figure 4. Demand assignment systems, as described for example in reference 7, operating at about 2 GHz are most appropriate for this role, with current proprietary systems capable of serving up to 1000 customers. Ideally, the central station is located at the processor node and small communities of customers can be served by pole-mounted outstations. Larger, village communities may be served by higher-capacity rack-mounted outstations located at the historical local exchange site. Where the geographical location of the processor and rural customers does not permit a direct radio path, repeater equipments may be used to extend the system coverage area.

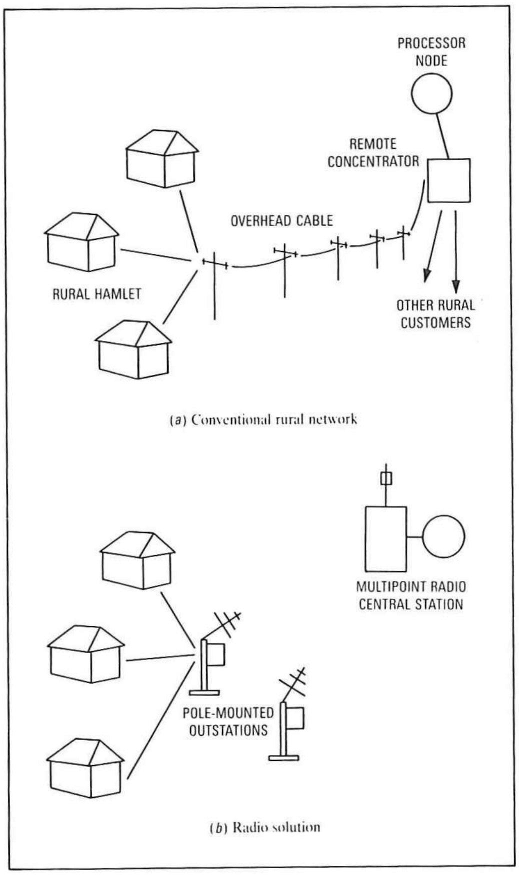


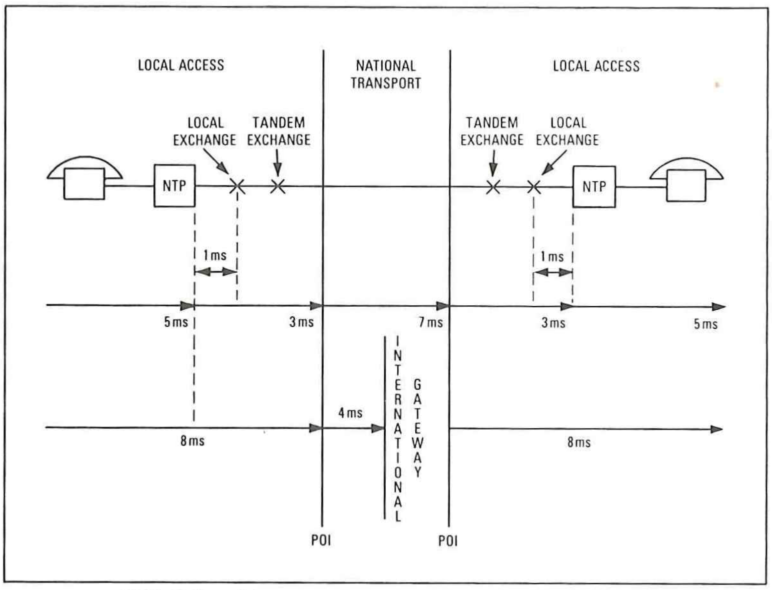
Figure 4—Use of multipoint radio in the rural local network

Trials of both small scale (100 line) and large scale (500 line) multipoint systems have been set up in British Telecom's Westward and Lancs & Cumbria Districts. An important element of the trials has been to assess the ability of local District staff to work with radio technology. The successful installation of these trial systems with limited Head Office involvement has demonstrated that radio can be handled confidently in the field. A number of lessons have been learnt from both the field exercises and technical studies which will be used to influence future design and implementation policy for multipoint radio systems in the British Telecom network:

Outstation capacities Firstly, particularly for the larger-scale systems, the capacity of the outstation (16 lines) has caused difficulties; in order to amalgamate sufficient customer lines together to provide a reasonable fill of the 16-line outstation, it has been necessary to retain and reconfigure a substantial amount of local distribution plant. The object of eliminating the problematic overhead distribution has not been achieved, and expected cost and quality improvements will be diluted. Ideally, an economic one-line outstation is required and this is referred to later.

Transmission delay Secondly, problems have been uncovered with respect to incompatibilities between the transmission delay incurred by multipoint systems and the British Telecom echo control model. The TDMA framing typically used by the large-scale multipoint radio systems introduces a one-way transmission delay of 8–12 ms. British Telecom limits the maximum national one-way delay to 23 ms, hence avoiding the need for echo control devices other than at international gateways. With the liberalisation of telecommunications in the UK, it has been necessary to agree with the regulators and other operators an apportionment of the overall delay between the constituent parts of the network. This is illustrated in Figure 5, which shows that multipoint systems break the one-way delay allocation for the local part of the connection. A number of solutions to this problem are under study.

Exchange interface The trial systems have been connected to the network by means of analogue single-line interfaces into the local switch. Although this arrangement is technically satisfactory, the radio central station has to de-concentrate the traffic in order to present single-line interfaces. A more elegant solution would be a direct concentrated traffic interface between radio and switch at the 2 Mbit/s level. Such an arrangement provides substantial savings in line card costs at both the radio central station and at the switch. To implement a concentrated interface, the radio must provide a signalling system compatible with the parent exchange. In British Telecom, this implies the use of either the proprietary CCITT No. 7 signalling system or the public DASS2 interface.



POI: Point of interconnect
NTP: Network terminating point
Total maximum national delay = 23 ms
Total maximum delay to international gateway = 12 ms

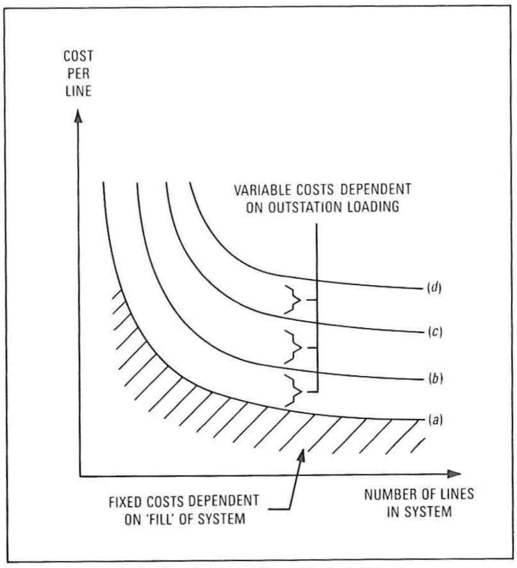
Figure 5
PSTN delay limits

None of the currently available multipoint systems provide such interfaces and development of a signalling system will only be viable if a large-scale use of radio is anticipated. The point is not that the analogue interface is a particular barrier to the use of multipoint radio, rather that the benefits of a concentrated 2 Mbit/s interface can only be realised with volume application of radio.

Numbering and tariffing 2 GHz multipoint radio has a potential range of up to 50 km, or considerably more if repeaters are employed, and can easily cross many existing exchange area and charge group boundaries. This could cause problems with numbering schemes and tariffing, particularly where radio is used to pick up only small groups of customers and parent them onto a distant exchange. The scale of these problems is likely to depend on the particular application of radio, and for temporary or expedient use it may be preferable to accept these problems rather than being unable to provide service at all.

Economic studies Economic studies have revealed only a limited scope for application of multipoint radio in rural modernisation. The basic cost-per-line characteristic of multipoint systems is shown in Figure 6 which clearly demonstrates the need to provide an adequate 'fill' of customers on a system in order to keep the cost-per-line down. A second feature of the cost curves is the increase in cost-per-line arising from the use of smaller outstations. A detailed analysis using current radio costs has shown that large-scale (up to 1000 line) multipoint radio is comparable in cost to conventional RCU and copper cable solutions for rural exchanges up to around 250 lines. Above this size, RCU solutions are generally cheaper. In order to maintain an economic fill, therefore, a single radio system would need to cover several small exchange

Figure 6
Typical multipoint radio cost curves



(*a*) Fixed cost of central station
(*b*) 64 lines per outstation
(*c*) 16 lines per outstation
(*d*) 8 lines per outstation

areas. Although the straight economics show some potential for radio, in reality, modernisation of rural exchanges is already proceeding with UXD5 and RCU solutions. Radio could be considered for the remaining analogue exchanges, although geographical difficulties in combining several exchange areas into one radio coverage area further limits the scope of application of radio. The economic study has concluded that, apart from a few specific areas such as the North and West of Scotland, where there are particular terrain problems, multipoint radio will not find general application for rural modernisation. Although this is a somewhat negative result, the trials have revealed some potential for using multipoint radio as a wide area overlay, providing service around local cable troublespots, overcoming planning shortfalls, and for temporary and emergency applications. In these cases, other factors than just minimising costs are important, such as the ability to provide fast service under competitive threat. Also, the ability to rectify poor quality routes using overhead cable will improve customer image and reduce maintenance costs.

Future Use of Multipoint Radio

Multipoint radio systems are now being actively considered for modernisation of very remote rural areas in Scotland. Several schemes to replace existing analogue plant are currently under study. In addition, detailed consideration is being given to a scheme for providing a District overlay using multipoint radio. A wide-scale use of multipoint radio is unlikely in the near future as already explained, and the problems of transmission delay and numbering/tariffing will need to be addressed if the schemes described are to go ahead.

Although the trials of current proprietary equipment did not succeed in totally eliminating the copper distribution, the ambition to reach remote customers directly via radio still remains. The ideal concept is of some kind of radio distribution station located in the field and connected, possibly by fibre, to the nearest convenient node of the network. Individual customers would then have radio terminal equipment which could be mounted on their premises and be locally powered. In design and implementation, such a system probably falls some way between the present multipoint technology and the emerging new generation of cordless telephones (CT2). The basic requirements of such a system are:

- compatibility with basic UK telephony standards,
- operates over rural distances of 10–20 km, and
- cost-per-line less than £500.

A survey of potential proprietary supplies for this 'one-per-customer' system has shown a number of promising designs, using FDMA or TDMA techniques and bringing techniques developed for mobile terminals into the fixed application area. Currently, all of these designs have some significant drawbacks, such as limited traffic capacity, operation in mobile-only frequency bands, the use of non-standard speech coding techniques, and/or high cost per line. Nevertheless, it seems feasible that technology advances in the next few years will provide a suitable solution.

CONCLUSIONS

The application of two main classes of microwave radio system in the access network, viz. point-to-point and point-to-multipoint systems, has been described. In the point-to-point case, particularly, the use of 18 GHz links has proved highly practicable and cost effective as a means for linking customer sites to network nodes. The new generation of equipment is easy to plan, install and maintain, such that radio links are now being used with confidence.

Point-to-multipoint systems are under active study and trial, and although evidence to date shows a rather limited scope for current multipoint technology, there remains a potential use of such systems for local network overlay applications. The case for multipoint radio at present is marginal, but with the apparent convergence of fixed and mobile technology, the prospect for a later generation of customer radio distribution systems looks quite bright.

ACKNOWLEDGEMENT

Acknowledgement is made to the Director, Network, British Telecom UK, for permission to publish this paper.

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Biography

Fred Harrison is currently a Head of Group responsible for microwave radio systems engineering within the Network Systems Engineering and Technology Department, British Telecom UK. He joined the then Post Office in 1974 as a student and, subsequent to studies at Southampton university, he was involved with the development of early optical transmission systems. He moved to his current work in 1985 and now has particular responsibility for the specification and approval of low-capacity radio systems for use in the access network.

The Highlands and Islands Initiative

INTRODUCTION

An ambitious multi-million pound communications project for the Highlands and Islands of Scotland, unveiled by Malcolm Rifkind, Secretary of State for Scotland on 2 June 1989, owes its success to a unique partnership—and a lot of foresight.

The £16M Highlands and Islands Initiative, which will put the remote rural areas on an equal footing with the major cities of Europe, can be traced back to the early-1980s, when the Highlands and Islands Development Board (HIDB) realised that telecommunications offered major opportunities, but also posed a threat to the rural region it represented.

In 1985, the HIDB and OFTEL—the Office of Telecommunications—commissioned telecommunications consultancy EOSYS to review the state of the telephone network in the region and identify its suitability for the new generation of value added and data services for both business and community use.

As expected, the report revealed that the network in the Highlands and Islands offered very good quality for voice services, with a lot of it recently modernised, but unfortunately the work had been completed just before the digital revolution. The EOSYS report concluded that it was imperative for the economic and social development of the region to provide access to advanced data services as soon as possible.

The recommendations were discussed at an open conference, jointly hosted by the HIDB and OFTEL, in Inverness in September 1986. At this point, BT, which also wanted to ensure that the region was not left behind in the digital progression, stepped into the arena and the unique partnership was established.

Typical Highlands and Islands location

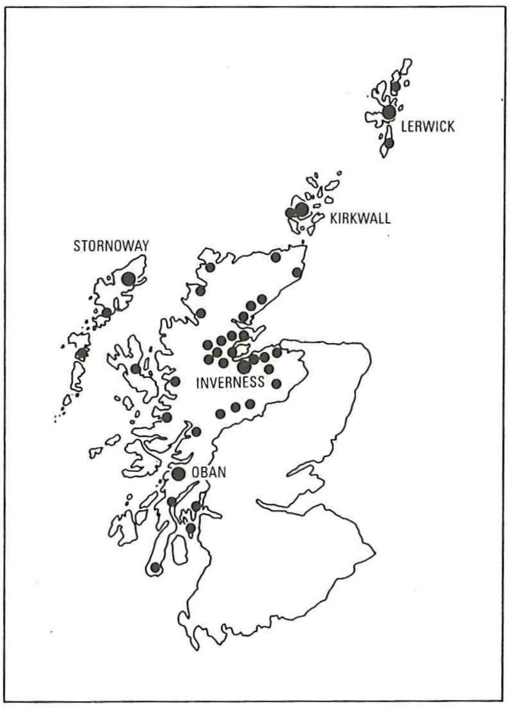
Three years hard work on research and arguing the region's case for assistance paid off when the Scottish Secretary announced that the Government had agreed to the HIDB's proposal to part fund the Highlands and Islands Initiative.

The full three-year programme to build the new digital network will cost £16M, with the HIDB contributing £4·9M. The Initiative will contain three distinct elements:

- integrated services digital network (ISDN),
- data access network, and
- Network Services Agency.

INTEGRATED SERVICES DIGITAL NETWORK (ISDN)

The bulk of the £16M investment will be in the telephone network infrastructure, the backbone of the Initiative. The three-year programme, which started in June, will provide digital exchanges and make full ISDN available in 43 Highlands and Islands locations (see map), from Lerwick in the north to Campbeltown in the south. The trunk and junction networks serving the ISDN exchanges will be upgraded to full digital standards, with two levels of access available to the network, either through single- or multi-line systems.



43 Highlands and Islands locations for digital exchange and ISDN provision

Primary access will be available under the BT product name *Multi-line IDA* (Integrated Digital Access) at modernised exchanges. This consists of thirty 64 kbit/s channels in a 2 Mbit/s PCM system using BT's DASS2 signalling system. The latest generation of private branch exchange—the ISPBX—which has sophisticated telephony facilities as well as data-handling capacities, can be connected to the ISDN.

Basic access (I.420) will be available via BT's *Single-line IDA* at modernised Highlands and Islands Initiative exchanges following the national product launch. Basic access is provided by a digital transmission system using ordinary telephone lines. It offers two 64 kbit/s channels and the flexibility of combined speech and data transmission. By using a standard interface, eight terminals can be connectable via one network connection, without the need for modems.

Teleservices supported by ISDN include high-speed high-quality data transmission (enabling applications such as the transfer of graphics, CAD/CAM programmes), Group 4 facsimile, slow-scan television, photo-videotext and electronic funds transfer at point of sale (EFTPOS). In the near future, video-telephony and video conferencing is expected to be available on basic access ISDN, bringing both services within the reach of most business users.

Business and residential customers served by digital exchanges will receive a high-quality service in terms of performance, speed, quality and range of services. They will have access to a range of services known as *Star Services.* There are eight Star Services, including call diversion and three-way calling. Itemised billing will also be available.

DATA ACCESS NETWORK

The data access network will provide high-quality access to the public data network and the Network Services Agency for the price of a local telephone call. Service is likely to be provided to all parts of the Highlands and Islands during 1990.

NETWORK SERVICES AGENCY

The Network Services Agency—expected to be operational by the end of this year—will provide both the hardware and the expertise to allow firms to make the most of information technology (IT) applications. It will be managed by NSA Ltd., a new BT subsidiary company, operating with the close co-operation of the HIDB. It will provide a sophisticated managed host computer system for the development of IT applications and value added data services within the region.

System hardware, based on the VAX 8360 processor, manufactured by Digital Equipment Company (DEC), is fully duplicated to guarantee maximum reliability. System software will include the all-in-one management package, VAX-Notes, CoSy conferencing software and RDB database package, supported by a flexible billing and accounting system.

Serving the computer will be a highly sophisticated communications system designed by BT and DEC. Initially, it will cater for 80 simultaneous users, but this can be increased with demand. User communications options to the agency will include private circuit, direct PSTN dial-up and the data access network provided under the Initiative.

NSA Ltd. will provide expertise and support to Highlands and Islands businesses in the development of applications of information technology. An early example of this is Alternative Data, of Findhorn, who plan to use the NSA computer to operate an on-line user support service for a major computer manufacturer.

CONCLUSIONS

The Highlands and Islands Initiative will provide the region with a network and services as advanced as anywhere in Europe by the all-important date of 1992. It will be up to entrepreneurs in the region to exploit the new network and reap the benefits, bringing new investment and jobs to the region.

Prioritised Remote Exchange Alarm Management—A New Approach

Traditionally, remote exchange management has tended to be rather hit or miss, with little information on the alarm type being known. At times of low alarm activity, corrective attendance has been on a first-come-first-served basis. In times of crisis, such as during electrical storms, alarm loadings far outstrip manpower and out-of-service exchanges can be left waiting while less urgent or even trivial alarms are dealt with.

With such a low level of intelligence about the nature of alarms reported to remote exchange alarm centralised management, it was inevitable that efficiency would remain low and the maximum use of engineer skills would not be achieved.

In late-1987, a joint venture between BT East Midlands District and manufacturers, Rotadata Ltd. of Derby, looked to overcome these problems. The result of this development is the REAMS 500 system which is now licenced for use by BT's Operations Support Centre Functional Working Group (OSCFWG).

REAMS 500 is a complete remote exchange alarm management system. In addition to exceptional cost effectiveness at typically £300 per exchange module, it features major advances over other systems such as: coverage of up to 500 remote exchanges each with 15 alarms; time stamping and prioritised alarms; no use of private lines; advanced call-out and rota management; and, finally, comprehensve statistics.

The REAMS 500 is a hardware/software system controlled by a Tandem 286 microcomputer. The system interfaces with a local alarm concentrator (LAC) at each exchange by polling via PSTN lines. The design polling period is every 15 minutes for 500 exchanges. The system does not tie up expensive plant or use private lines and has a very short holding time therefore generating minimum traffic.

The system can handle 15 alarms from each exchange. These are prioritised into high, medium and low levels. All exchanges on the system are represented on a computer graphic display screen. Exchanges with an alarm or alarms tripped are highlighted in colour, red for the highest priority, green for the lowest. Further graphic screens show the type of alarm or alarms at each exchange. Normally only red, critical priority alarms are dealt with by call-out engineers other alarm levels being left for on-site engineers.

REAMS 500 remote exchange alarm management system

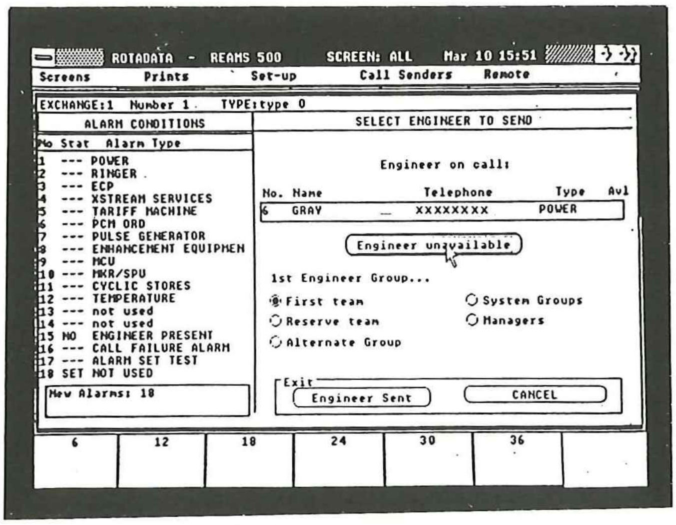
In addition to monitoring alarms, REAMS provides eight control channels to enable remote resets or changeovers, and the switching on of traffic recorders, call senders, outside lights etc.

Engineers call-out rota lists are an important and integrated part of REAMS enabling effective use of manpower resources. All known rota systems are catered for and up to 500 engineers in up to 200 groups can be managed.

Comprehensive management statistics covering such as, all alarms, all attendances and times are produced as daily statistics to supervisor level. Additionally, for further analysis, the computer holds a historical data record of the most recent 200 faults for each exchange.

Three REAMS 500 controllers are already fully operational in the East Midlands in the Leicester, Nottingham and Peterborough areas, covering some 300 exchanges. During the night, the whole District is to be managed from a single point at Leicester, with interfacing to Nottingham and Peterborough units by modem. Mr. Harry Shillitto, Senior Manager responsible for REAMS in the East Midlands has certainly found the benefits of the system. He comments 'Prior to the introduction of the REAMS system and in order to eliminate the risk of service failures, all alarms had to be attended as they were not classified. Now engineers attend only the critical ones giving considerable savings in time and money—we could not afford to be without it.'

The REAMS system also compliments the Rotadata ANA Mark II Automatic Network Analyser for monitoring and controlling the network. Interfaces for REAMS are also envisaged for information entry directly to BT networking facilities.



Typical screen display

IBTE/FITCE Regional Seminar: Open Network Provision

INTRODUCTION

On 23 June 1989, at the Logan Hall, University of London, a seminar promoted jointly by the London Centre of the Institution of British Telecommunications Engineers (IBTE) and the UK Group of the Federation of the Telecommunications Engineers of the European Community (FITCE) was held on the subject of Open Network Provision (ONP). The seminar was sponsored by London Network Operations. Chris Seymour, Chairman of the London Centre of IBTE, opened the seminar and welcomed the large audience of IBTE Members and their guests.

PAPERS

The focus of the day was the presentation of four papers by one British Telecom and three European colleagues. Peter Hamelberg, Director of Standards and International Affairs, Netherlands PTT, and President of FITCE, presented the first paper entitled 'FITCE Looks into the 1990s'.

He began by reviewing the historical background of the formation of FITCE. He restated the objectives of FITCE, and explained how these are achieved via the annual Technical Congresses, by the Review, by study commissions, and by the informal network of contacts built up by participation in FITCE activities. He reviewed changes in the technology of telecommunications and the environment in which telecommunications operation is taking place, particularly in Europe, and reflected on possible changes to FITCE that are being considered.

The second paper was presented by Claudio Carrelli, Head of Software and Switching Systems, Societe Italiana per l'Esercizio della Telecommunicazion and Chairman of Group d'Analise et de Prevision (GAP), and was entitled 'Open Network Provision: Concept in Europe'.

In his presentation he gave an overview of the concept of ONP as developed within the European Community. He stressed the fundamental role of telecommunications regulation for the promotion and development of telecommunication services. He described the activities undertaken by GAP (the analysis and forecasting group within the EEC) in the formulation of the ONP concept, and outlined its current programme of work. Issues raised by the so called 'ONP Trilogy' of technical interfaces, usage conditions and tariff principles were discussed. He also described the parallel concept of Open Network Architecture in the US and discussed the similarities with, and differences to, the European ONP approach.

Graham Oliver, Principal General Manager Standards, Research and Technology, British Telecom Technology and Development, presented the third paper entitled 'Technical Aspect of Open Network'.

In his presentation, he examined some of the technical aspects of the concept of open systems and open network architecture. He firstly stressed the need for standards in the field of telecommunications, and reviewed the different processes by which standards are created and imposed. He emphasised the need for an open approach. He described areas of technological development to be considered in future networks, and the RACE concept of Network 2000. He outlined the issues that need to be addressed in establishing the architecture of the future network. He described one particular architectural method, the 7-layer Open Systems Interconnection (OSI) model, and went on to discuss BT's open network architecture (ONA), with reference to BT's ONA products and services. He also described office document architecture, another part of the OSI family.

The fourth and final paper was presented by Gunther Altehage, Head of Switching Systems for Telephones and ISDN, FTZ. The title of his paper was 'Open Network Provision: Concepts and Technical Realisation Proposals for the Network of the Deutsche Bundespost Telekom.'

He outlined the German understanding of the objectives of ONP. He went on to describe two ONP application proposals: interconnection between the PSTN/ISDN of the Deutsche Bundespost and two new digital public land mobile networks, based on the GSM specification, that are to be established, one by the Deutsche Bundespost, and the second by a licensed non-postal operating agency; and packet-switched access via the ISDN to the Telekom data network and to services provided by private service operators.

Detailed articles based on the four presentations are printed in the *Supplement*.

FITCE AND IBTE

After the four papers, Brian Wherry, Vice President of FITCE, addressed the delegates. He posed the question of why professional engineers within the UK had a much lower status than colleagues in Europe. The view was given that the situation was gradually worsening and that the specific standing of telecommunications engineers within operating companies and in industry seemed to be suffering. Engineers needed to address this problem.

IPOEE/IBTE first came into being to satisfy the need among early telecommunications engineers to keep up-to-date in a world of rapid technological change. There was a feeling of a need for self-help outside of formal, then Post Office, training. Through meetings of Local Centres and the presentation of papers, IBTE Members exchange ideas and knowledge on the state of the art to the mutual advantage not only of themselves, but also to industry and the communications world. FITCE has the same role and basic objectives.

The objectives of FITCE are to further the growth of science in the field of telecommunications, to further cultural bonds and to encourage friendly relationships between engineers who belong to the member associations, to enable each member to benefit from the experience acquired by the other members in all telecommunications fields and to investigate new ideas which will encourage the development of telecommunicaions in all the countries represented.

Gunther Altehage making his presentation

Brian went on to describe FITCE activities that would help to redress the balance and stimulate interest in IBTE and within other associations across Europe. Firstly, IBTE is hosting, for the very first time, the annual FITCE Technical Congress in Glasgow in August 1990. About 30 papers will be presented on a theme which almost certainly will deal with, and relate to, the architecture of the network, the peripheral facilities that this offers to customers and the commercial consequences and advantages to British Telecom. Secondly, IBTE is organising further Regional Congresses. Thirdly, an attempt is being made to set up bilateral technical exchange visits between countries within the Federation. Finally, there is the FITCE Review.

The point was underlined that FITCE does tend to concentrate and to cater for field operational engineers perhaps more so than those at Headquarters or, for example, at Martlesham Heath, who get an opportunity to converse with colleagues through CCITT and CEPT committees.

Colin Shurrock, Chairman of the IBTE Council, then addressed the meeting. Colin emphasised the high reputation that British Telecom engineering has, that IBTE has, both in the UK and, through the *Journal,* throughout the world. IBTE's objectives—to support and encourage its members in the search for engineering excellence—has to be, fundamentally, a partnership both between members and with British Telecom. IBTE derives its position in the company from the motivation of the members over the years to develop their skills and expertise, and from the recognition of BT of its need for excellent engineers.

IBTE is, in many ways, an agent for change. Telecommunications is changing at a phenominal rate, and IBTE has to respond to that change; for example, education has changed significantly, and the needs of the membership have changed correspondingly. There is a need to understand and relate to, much more closely, collegues in marketing and commerce and in Europe. He underlined IBTE's support for the seminar and said that he was delighted to work with FITCE in the UK promoting the exchange of ideas in Europe.

The changes taking place are reflected in the content of the *Journal* and in IBTE Local Centre activities. However, changes have reached a situation where it would be useful to review IBTE's position and the way in which IBTE can be involved in going forward. With the IBTE's President, Clive Foxell, he will be taking part in a review, firstly with senior engineers in BT. This will involve Council and members throughout the company.

IBTE has some 11 000 members and promotes its activities principally through the Library, the *Journal* and its Local Centres. The *Journal* covers all aspects of telecommunications and each publication numbers about 30 000. The general opinion of the *Journal* is that, while some improvements can be identified, it is recognised as being one of the major definitive sources of telecommunications developments.

The Local Centres represent a vital activity in the life of the IBTE. The 24 Centres spread throughout the UK organise a total of some 125–130 meetings and lectures during the course of a year. This says a great deal for the interest shown and for the enthusiasm of the individual Local Centre officials.

ROUND TABLE DISCUSSION

The last part of the seminar was given over to a round table discussion on the open network concept. Chairing the discussion was Bill Medcraft, Territory Chief Engineer of London and South East England. Bill began by introducing the team of participants who were: Cor Berben from the European Community; Peter Walker, Director of Planning, British Telecom International; Peter Mackie, British Telecom Headquarters Government Relations; Michael Doig, Head of Value Added Data Service Licensing Section, OFTEL; John Metcalfe, Department of Trade and Industry, Telecommunications Branch; and Peter Allen of American Express and Vice Chairman of the International Telecommunications Users Group. The members of the team were each invited to speak for five minutes and make specific points that they considered important in the sphere of open networks.

Peter Allen John Metcalfe Michael Doig Peter Walker
Cor Berben Bill Medcraft Peter Mackie

Round table discussion team

There followed considerable general discussion on various aspects of ONP. An edited transcript of the round table discussion is also printed in the *Supplement.*

CLOSING ADDRESS

The day's proceedings were summarised by Dr. Peter Bailes, Secretary of the UK FITCE Group, who stated that the day's discussions had been about the removal of barriers between BT, the development of BT's business into the European arena (and beyond), and participation in the removal of barriers between the UK and Europe. The competitive environment to be created by ONP will have a considerable influence upon the UK's attitudes, where there has been a tendency in the past to look to America for operational guidance.

If this opportunity is allowed to slip away, the UK will fall behind as an international contender in this market. BT must now look at Europe as well as America for its future potential markets.

It is individuals within companies, not companies as such which make achievements. These initiatives will only succeed if individual members of BT commit to overcoming the barriers which currently prevent us from grasping the European and International opportunities.

The competition will come in any case and there will be no-one in the company whom it does not affect. The opportunity which should be looked at is one of personal development in readiness for 1992. The industry will become a global industry with frightening speed once the major barriers disappear.

There will be other FITCE sessions in York and Manchester in November, with perhaps other seminars in Martlesham and other parts of the country leading up to the Congress in Glasgow in August 1990.

Thanks were expressed to the many people who had contributed to the day's success among whom were named Millie Banerjee, District General Manager, London Network Operations; Chris Seymour and Chris Webb, Chairman and Secretary of the London Centre, respectively; and Dennis Peters, who is due to retire shortly, Dilip Modi and Anthony Oodam, London Committee. Also named were Tapash Ray, of Network, BTUK, who as FITCE Assistant Secretary has worked diligently on behalf of FITCE for the past year and a half; and Brian Wherry, although now retired, is still immensely active and has been a major driving force in the continued commitment behind these programmes.

THE INSTITUTION OF BRITISH TELECOMMUNICATIONS ENGINEERS

(Founded as the Institution of Post Office Electrical Engineers in 1906)

General Secretary: Mr. J. H. Inchley, NPW2.1.6, 4th Floor 84–89 Wood Street, London EC2V 7HL; Telephone 01–250 9816.
(Membership and other enquiries should be directed to the appropriate Local-Centre Secretary as listed on p. 280 of the January 1989 issue of the *Journal*.)

MR. R. E. G. BACK

The Institution has heard with deep regret of the untimely death of Mr. R. E. G. Back, President of the Institution from May 1984 until May 1988. Council join with his many friends in British Telecom in extending their fullest sympathy to his family.

Ron Back had, during his term of office, been a staunch supporter of the Institution, and his guidance and encouragement were much appreciated. His retirement last year from the Presidency was marked by the award of Honorary Membership. During the coming months, Council will be considering some form of fitting and lasting memorial to his IBTE involvement.

IBTE ANNUAL GENERAL MEETING

The Annual General Meeting of the Institution took place at the Chartered Insurers Hall, London, on 10 May 1989, and the new President, Mr. C. A. P. Foxell, took the chair. The text of his address, and the Annual Report of Council presented by the outgoing Chairman, John Tippler, will be printed in the Annual Report and Accounts 1988/89. Mr. Foxell took the opportunity at the AGM to introduce the new Chairman of Council, Colin Shurrock, and to wish him well in his new task. He then went on to present, on behalf of Council, Honorary Memberships to:

- John Tippler, who in his role first of President of the Associate Section (1983–1987) actively and vigorously championed and fostered the Associate Section, leading to an increased vigour and enthusiasm across the Districts, and as Chairman (1987–1989) has encouraged and developed new initiatives to increase Membership of, and interest in, the Institution.
- Denis Sharman, who served for an astonishing twenty years as Honorary Local Secretary of East Midlands Centre, as well as serving for a term on Council as Midlands representative. Both his Local Centre, who warmly recommended him for his award, and the whole Institution owe Denis a great debt of gratitude for his dedication and service. His experience and support have been of immense value to several generations of Council Officers.
- Donald (Don) Randles, who served with distinction as Local Centre Secretary of South Wales Centre for ten years, during which time he rendered invaluable service to the Members of his Centre, as well as inspiring enthusiasm for the Institution with all whom he came into contact.

Finally, he referred to the outstanding service of Brian Wherry, who has been respectively: London Honorary Centre Secretary (1962–66), Institution Secretary (1966–78), Vice Chairman of Council (1980–89), and Member of the Comité de Direction of FITCE—an unparalleled record of service and commitment. Brian, unfortunately unable to be present, had been created an Honorary Member of the Institution in 1978 following his term of office as Secretary. However, Council had marked the occasion of his retirement from IBTE with a special award of a commemorative medal and scroll. Brian will, we hope, be continuing his association with the Institution through his activities in chairing the organising committee for the 1990 FITCE Congress in Glasgow.

COMPOSITION OF THE COUNCIL 1989–90

Chairman: Mr. C. Shurrock.
Vice-Chairman: Mr. A. F. Beardmore.
Honorary Treasurer: Mr. P. A. Allen.
President, Associate Section: Mr. A. G. Bealby.
Secretary: Mr. J. Inchley.

Representatives:

Mr. G. Taylor, London 1.
Mr. A. Oodan, London 2.
Mr. J. M. Griffiths, Martlesham.
Mr. D. McMillan, Scotland.
Mr. S. Brewis, North East.
Mr. D. Hulse, North West.
Mr. R. Sutton, Midlands.
Mr. H. Topping, Northern Ireland.
Mr. R. N. Williams, Wales.
Mr. T. Jeannes, South West.
Mr. R. Henderson, South East.
Mr. K. J. Woolley, East.

Co-opted Member: Mr. D. C. Sharp.

RETIRED MEMBERS

Members about to retire can secure life membership of the Institution at a once-and-for-all cost of £10·00 and so continue to enjoy the facilities provided, including a free copy of this *Journal*. Enquiries should be directed to the appropriate Local-Centre Secretary.

THE INSTITUTION OF BRITISH TELECOMMUNICATIONS ENGINEERS

(Founded as the Institution of Post Office Electrical Engineers in 1906)

IBTE/FITCE REGIONAL SEMINARS

CALL FOR PAPERS

The FITCE Group of IBTE is inviting prospective authors from British Telecom to submit technical papers on the following theme with a view to present them at the forthcoming IBTE/FITCE Regional Seminars to be held at several centres in November 1989:

'The Importance of Network Architecture in the Development and Management of International Services'

Specific topics will include:

- The structure of telephony networks in Europe.
- The structure of ISDN and advanced data services networks throughout Europe.
- The structure of the management systems which control network operation and growth.
- The impact of different architectures on the management of services for national and international customers.
- The creation of new products using the increasing levels of intelligence within the network to meet customers' requirements.

The selected authors will be given the opportunity to present the same papers to an international audience at the 29th European Telecommunications Congress to be held at Glasgow in August 1990.

For further information please contact Tapash Ray, Assistant Secretary FITCE, BTUK/NPW3.2.5, 2C75, The Angel Centre, 403 St John's Street, London EC1V 4PL. Telephone: 01–239 0429. Fax: 01–239 0426.

YORK AND MANCHESTER SEMINARS

The FITCE Group of IBTE in conjunction with the Yorkshire and Lincolnshire Centre and Manchester Centre is organising two half-day Regional Seminars which are due to be held on Tuesday 28 November 1989 at Tempest Anderson Hall, Museum Gardens, York, and then on Wednesday 29 November 1989 at Reynold Building, University of Manchester Institute of Science and Technology. Both seminars will commence at 14.00 hours and end at 17.00 hours.

It is expected that invited speakers from Europe will attend the seminars and present technical papers. Authors from the UK interested in presenting papers should note 'Call for Papers' above.

For further information on these seminars please contact:

Mr. Richard Kirby, Secretary, IBTE Yorkshire and Lincolnshire Centre, BTUK/North/NO3, Netel House, 6 Grace Street, Leeds LS1 1EA. Tel: 0532 466366. Fax: 0532 442323.

Mr. Malcolm Asquith, Secretary, Manchester Centre, BT Manchester District, NE20, Telecom House, 91 London Road, Manchester M60 1HQ. Tel: 061–600 5171. Fax: 061–832 3812.

FITCE

Institution of British Telecommunications Engineers

Associate Section National Committee

16th ANNUAL NATIONAL TECHNICAL QUIZ FINAL AND AWARDS DAY, 1989

Friday 21 April saw the culmination of all the Associate Section national competitions at the Institution of Electrical Engineers, Savoy Place, London.

The programme was opened by the Associate Section Chairman, Norman Clark, who welcomed the large audience and introduced the guest of honour, John Tippler, then Chairman of the IBTE Council and a former Associate Section National President.

The first item on the agenda was an audio-visual presentation entitled 'Telecommunications Transmission—The Fibre Optic Future' and presented by Dr. Peter Cochrane, Division Manager, Main Optical Network, British Telecom Research Laboratories. This gave the audience an insight into the development of the optical-fibre network and the achievements that have been attained.

Next on the agenda was the 16th National Technical Quiz Final, organised by the National Quiz Organiser, Howard Duggan. The Chairman introduced Alan Bealby, President, National Associate Section, who acted as question master for the event.

The final this year was between teams from Manchester and British Telecom Technical College (BTTC) Stone, the culmination of 10 inter-District rounds representing 88 Centres. The final was keenly contested by the two teams, but, at the end of the day, the Manchester team emerged as clear winners. John Tippler presented the Bray Trophy to the Manchester team. He also presented individual trophies to the members of the team, and congratulated them on their success in the competition. He went on to present individual trophies to the members of the Stone team and congratulated them on their splendid achievement in reaching the final.

Officials for the quiz were:

Adjudicators:	Ken Crooks, Vice-President, Associate Section Jon Inchley, Secretary, IBTE Council
Time Keeper:	Mike Hughes
Scorer:	Peter Hewlett

Then followed the presentation of the remaining National Competition awards. They commenced with the Anning Trophy, named after a former Associate Section National Committee officer who died suddenly at an early age. To perpetuate his memory, the National Committee presented a trophy to be awarded annually to the Young Member of the Year. This year, the winner was Alex Mackintosh of the Ayr Centre and the trophy was presented by John Tippler.

The next presentation made by John Tippler was to Martlesham Centre, winners of the Cotswold Trophy, an award presented to the Centre deemed to have most furthered the aims of the Associate Section.

Brian Comber, National Project Organiser, introduced entries for the National Project Competition winning entries. First was the E. W. Fudge trophy, presented annually for the best non-computer entry.

The winning project this year was chosen for its technical competence, sound engineering, ingenuity and for solving a real problem. An existing complex tester was controlled remotely by a computer, all interfacing being designed to leave the circuitry of the tester unchanged, while allowing errors to be checked fully. All displays on the tester were checked and cleverly mimicked back at the controlling computer. The winners were Steven Leask and David Mclean for their project, DICE 2, and the presentations were made by E. W. (Ted) Fudge.

Manchester team with Bray Trophy

BTTC Stone team

The winner of the London Trophy tackled the problem of the large volume of statistics produced by System X exchanges, each producing about 120 pages per day. To produce data from this to allow management decisions to minimise congestion was a mammoth task. He saw this as obvious work for a computer to give a quick and meaningful output, where parameters could be altered at will. He decided not to use the ubiquitous BASIC because of the speed required in this operation, and likewise none of the solutions at hand, such as dBase III, were fast enough or friendly enough to encourage use. He therefore wrote a very good and popular program in PASCAL which has now been adopted in 20 Districts.

John Tippler presented Colin Blackett with the London Trophy, for his winning entry of SAM—Statistical Analysis for Management.

The Chairman concluded the event by thanking the guest of honour, officials and everyone who had attended for making it such a successful day. He also thanked all the participants in the National Competitions for their efforts which contributed so much to the success of the Associate Section.

The day concluded at the Ramada Hotel, London, with the National Award Dinner.

1990 17th NATIONAL TECHNICHAL QUIZ

The draw and dates for the Associate Section 1990 17th National Technical Quiz are as follows:

Round 1 13 December 1989
North East v East
Scotland v Wales

Round 2 17 January 1990
North East or East v Scotland or Wales
North West v Northern Ireland
South West v London
Midlands v South East

Round 3 14 February 1990

Final 20 April 1990

Rear row: Roy Parton, Treasurer; Alan Johnstone, Secretary

Gary Ming, Vice-Chairman; Howard Duggan, Quiz Organiser; Richard Craig, Asst. Secretary; Ken Crooks, Vice-President

Terry Turner, Asst. Treasurer; Warwick Flury, Editor; Brian Comber, Project Organiser

John Tippler, Chairman of Council; Norman Clark, Chairman; Alan Bealby, President

IBTE Associate Section National Executive Committee, 1989

ASSOCIATE SECTION NATIONAL EXECUTIVE COMMITTEE

The following is a list of the national officers to whom enquiries concerning the Associate Section should be addressed:

Chairman	N. V. Clark	LNO/NEW38, Wembley TE, PO Box 4, London Road, Wembley, HA9 7EY. Tel: 01−902 1112, 01−903 2133. Fax: 01−902 6868.
Vice-Chairman	G. Ming	Telephone Exchange, Irish Street, Waterside, Londonderry BT47 2JA. Tel: 0504 44444.
Secretary	A. Johnstone	TNO/S252, Woodcroft TE, Pitsligo Road, Edinburgh EH10 4RZ. Tel: 031−667 8467, 031−447 8490 Extn. 56. Fax: 031−447 3821.
Assistant Secretary	R. Craig	EN15, BT, Guild Centre, Third Floor, Lords Walk, Preston PR1 1BA. Tel: 0772 267236. Fax: 0772 201262.
Treasurer	R. Parton	Stafford Walton ATE, Eastgate Street, Stafford, Staffordshire ST16 2LY. Tel: 0785 46330, 0785 662211.
Assistant Treasurer	T. Turner	72 Putteridge Road, Stopsley, Luton, Bedfordshire LU2 8HP. Tel: 0345 333111. Display Pager 0774759.
Editor	W. Flury	RT2221 B10, Room 68, BTRL, Martlesham Heath, Ipswich IP5 7RE. Tel: 0473 645118, 0473 643210.
Quiz Organiser	H. Duggan	EP382, Room 109, 25 Pendwyallt Road, Coryton, Cardiff CF4 7YR. Tel: 0222 379732. Fax: 0222 625666.
Project Organiser	B. Comber	LNO/NNS15, Edinburgh House, Room 101, 154−182 Kennington Lane, London SE11 4BZ. Tel: 01−621 4032, 01−621 4239. Fax: 01−633 0743.

British Telecom Press Notices

New Codes for London Telephones

The London 01 telephone area will be divided into two from May next year as BT acts to meet the accelerating demand for new telephone numbers.

The code in the inner part of London, within an approximate four mile radius of Charing Cross, and including much of Docklands, will change from 01 to 071. The remainder of the present 01 area will become 081. Sunday, 6 May 1990—the May Day Bank Holiday weekend—has been chosen for the change-over date to minimise disruption. The new codes will double the pool of available telephone numbers to meet the growth in demand. Call charges will not be affected by the code change.

BT has given customers, and everyone else who will be affected at home and overseas, a full 12 months notice to help them prepare for the changes. BT's main concern is to ensure that inconvenience is kept to a minimum. A concerted publicity programme will keep customers fully informed at every stage of the change-over. This has included individual letters to all London 01 telephone customers advising them of their new code, national newspaper advertising, and the distribution of free, easy-reference tables. A free help-line to handle any remaining customer enquiries is also available, 0800 800 873, operating between 09.00 and 21.00 hours, seven days a week.

For a period following the introduction of the new codes, wrongly dialled calls will be greeted by recorded messages advising callers to dial again, and informing them of the correct code. These will operate until it is clear that customers have become familiar with the new arrangements.

Additional London telephone numbers are required to meet:

- the explosive growth in demand for new telephones;
- the demand for new services such as modern office switchboards with direct-dialling-in facilities where each internal extension requires a dedicated telephone number; and
- the wider usage of facsimile machines.

More than 400 000 additional telephone numbers have been provided for in London over the past year.

BT has looked closely at how other parts of the world have tackled the same situation and is introducing the simplest, easiest-to-understand, and most convenient solution. Importantly, the scheme will not affect the customer's own telephone number.

Calls to Mercury Communications numbers will also require an 071 or 081 code.

The change has been accepted by the Office of Telecommunications (OFTEL) as being consistent with BT's licence obligations. These included detailed consultations in an industry body, the Telecommunications Numbering and Addressing Board, approved by OFTEL as representing the interests of all telecommunications operators, the telecommunications manufacturing industry, and user organisations.

British Telecom Provides World Standard for Data Compression

BT's data compression technology—a way of achieving significant economies in data transmission over telephone lines—has been selected as an international standard.

The technique—developed by BT's Datacomms Division—is to be incorporated in an addendum to the V.42 Recommendation for modems with error correction drawn up by the CCITT. The addendum will be designated V.42*bis*. BT's system for data compression will enable V.42 modems to transmit three to four times as much data in the same timespan, and enable users to achieve significant savings in call charges. In certain applications, even higher data rates may be possible.

BT's compression algorithm, known as *BTLZ*, is based on a technique known as *Ziv Lempel compression*. It was chosen after the CCITT looked at four possible schemes besides the BT solution—the Hayes algorithm, the ACT CommPressor algorithm and Microcom's MNP Class 5 and MNP Class 7. The five algorithms were evaluated against two criteria—performance (that is, compression ratio) and implementation complexity. The BTLZ algorithm came top in both: it was easier to implement and faster than the simple Hayes and MNP Class 5 technologies, and its performance equalled the more complex MNP Class 7 and CommPressor solutions.

The idea of exploiting measurable characteristics of data in order to reduce transmission time dates back to the work of Morse and Vail in the 19th Century. They visited a local printer to find out the numbers of each letter used in typical text, and hence were able to design a code in which common characters (e and a, for example) had short codewords, and infrequent characters (such as v and j) long codewords.

Modern data compression techniques have moved on since the time of Morse. They can learn and dynamically adapt to the characteristics of the data being transmitted to give optimum performance.

Other types or data compression code have been developed in recent years, including the family of string-encoding algorithms. A string-encoding algorithm operates by replacing a string of characters by a codeword (typically 10 to 12 bits in length). String-encoding algorithms can potentially give very high compression ratios (as much as 10:1) but are generally complex to implement. Research into data compression techniques suitable for use in communications devices, such as modems, had been carried out some years ago in a BT sponsored project at Leicester Polytechnic, and subsequently within BT Datacomms Division. This research led to the development of a string-encoding algorithm based on the Ziv Lempel scheme, which proved to be simple to implement, very fast, and to give a good compression ratio.

The encoder and decoder each maintain a dictionary of strings, each string having an associated codeword. For example, a string such as the word 'the' would be coded 0110101010 and 'and the' becomes 0110101110 —the same number of digits—in code. The encoder matches a string of characters with a dictionary entry, replacing the string by its codeword. The decoder uses the received codeword to look up the string in its dictionary. The dictionaries are dynamically maintained during normal operation; new strings are added, and disused strings deleted.

British Telecom Takes the Lead in Vocational Training

BT has taken a lead in establishing vocational qualifications for the telecommunications industry. There are currently no industry-wide standards of competence.

BT, together with STC Telecommunications, GEC Plessey Telecommunications, Cable and Wireless, Mercury Communications, and Telephone Rentals, is setting up a body to act as a focus to determine standards of vocational competence throughout the industry. This lead body is in response to the Government's initiative on national vocational qualifications. Its main functions will be:

- to develop occupational standards and vocational qualifications in consultation with the National Council for Vocational Qualifications and to inform employers of the results;
- to encourage other organisations to participate, in order to command the support and co-operation of major employers in the telecommunications industry; and
- to provide a focus for the industry both in the UK and in the European arena.

BT initiated a series or meetings with other major telecommunications organisations to discuss implications for the industry. Five of the companies involved formed a consortium and commissioned a mapping study of the industry from Price Waterhouse.

The results show that the companies share significant common ground in the types of knowledge required and the main tasks performed across a range of telecommunications jobs.

The establishment of the body demonstrates the companies' commitment to the continued training and development of their own employees, a general concern for the future or the industry as a whole, and is an indication of the industry's response to the challenge that 1992 will bring.

When European-wide standards of competence are discussed, the UK telecommunications industry will now have a single voice to represent its interests. This important step will reinforce the industry's high training standards in the years ahead.

Centre for Excellence in Technical Training

BT's Technical Training College is to spearhead the use of new tough standards in training to ensure engineers can meet the challenges of the 21st Century. The college—Europe's largest centre for industrial training—will be one of the first to adopt the new standards of vocational competence for telecommunications.

Work on setting the standards is being led by BT in collaboration with STC Telecommunications, GEC Plessey Telecommunications, Cable and Wireless, Mercury Communications and Telephone Rentals. As the standards come to be agreed with the National Council for Vocational Qualifications, due to start next year, they will be applied by the College, which is officially recognised as a non-statutory training establishment. The new standards should be fully introduced by 1991.

The Technical College, with headquarters at Stone, near Stafford, provides training for BT's 120 000 engineering technicians. These install and maintain the company's network of exchanges, microwave radio links, and optical-fibre and copper-conductor cables, and most of the equipment connected to it, which includes telephones, teleprinters, office switchboards, modems, VDUs and computers. The training also covers associated activities, such as motor transport maintenance, office services, and safety at the workplace.

The college also offers consultancy and advice to other organisations—principally overseas telecommunications authorities—on training problems. It also attracts significant numbers of students from overseas. Every aspect of the company's technical activities is handled at Stone and at the other locations which together comprise the college. The other sites are in Harrogate (North Yorkshire), Shirley (West Midlands), Bletchley Park (Buckinghamshire), Shirehampton (Avon) and the City of London.

The college, which can accommodate just over 2000 students at any one time, provides between 110 000 and 120 000 student weeks of training a year, involving the attendance of 40 000 to 50 000 students. It can provide up to 750 separate courses and runs about 90 simultaneously.

On average, recruits to the company require basic training lasting from five to nine weeks. They then attend further courses as necessary, to be trained in extra subjects or new technologies.

As part of its facilities, the college has a digital network of five digital exchanges—three System X and two AXE10—linked to two operations and maintenance centres (OMCs). Further connections to digital PABXs and other customer apparatus enable the College to provide training in integrated services digital network operations and in integrated digital access.

The college has built a 172nd scale model of a typical local community—shops, offices, factories, houses, flats and public buildings, with streets, footpaths, parks, street furniture, etc. This is used for training in local network design, installation and maintenance.

BT has always sought to establish the highest standards of technical competence for its staff. It is natural, therefore, that it should be implementing the new standards for vocational competence in telecommunications right from the start.

The college is recognised by the British Standards Institution as an approved training establishment for SARCRAM, the scheme for approval and registration of call routing apparatus maintainers. In training the company's PBX maintenance staff to SARCRAM's high standards, the college made a significant contribution to BT's registration as an approved maintainer. BT is now giving training in PBX installation as part of the company's drive to gain registration as an approved installer.

In striving for technical excellence, the college seeks out and applies the most advanced teaching methods and aids. It is for example, one of the world's leaders in using computer-based training (CBT), which was introduced as early as 1976. About 7% of the courses use CBT, involving about 40 studies at any time.

The college uses WICAT's CBT system, which is modular in character. This allows students themselves under computer managed learning, to put together courses which match their knowledge of the particular subject. Level and knowledge is determined by tests; if students pass they do not need to take the appropriate course. At the same time, lecturers use computer-aided learning to design new courses.

The CBT courses are also available to BT's Districts, with terminals in local offices linked to the Stone mainframe computer. This enables staff to receive training at work, without the disruption of attending a residential course.

Customs Awards UK Facilities Management Contract

A £70M computer system to process the UK's trade with the rest of the world is to be developed and facilities managed by BT for HM Customs and Excise.

The new CHIEF system (Customs Handling of Import and Export Freight) will provide fast and efficient processing of goods entering and leaving the country and will be accessed by thousands of importers, exporters and freight forwarders. It will provide a comprehensive service for Customs in relation to the control of trade and the collection of revenue and will ensure that the vital flow of goods is uninterrupted.

The system will replace the existing DEPS (Departmental Entry Processing System)—also run by BT—and will operate throughout the 1990s providing new and enhanced facilities to customs and the associated trading community. In particular, it is designed to meet the major changes arising as a result of the single European market in 1992 and the opening of the Channel Tunnel.

Development work on the contract starts immediately and the first new facilities are scheduled to commence operations in May 1990. Further deliveries will be phased in over the following two years and the system will operate into the 21st century.

BT has a long established relationship with HM Customs and Excise in the development of world-leading freight processing systems. CHIEF will be vital to the UK's position in international trade for the next decade and BT is committed to ensuring its success. BT's twenty year record of service to the freight industry uniquely qualifies it to undertake this challenging and exciting project.

Link Awards Facilities Management Contract

BT has been chosen to help expand the capabilities of the LINK national cash network to enable 11 million cardholders to use 4200 cash dispensers throughout the UK. The five-year contract, worth more than £10M, is from Link Interchange Network Limited to run the UK's largest shared network of branded automated teller machines (ATMs).

The LINK network currently enables customers of 30 banks and building societies to use 1500 ATMs. It will grow to 4200 outlets during the next 12 months, when membership rises to some 38 financial institutions.

The Halifax Building Society and the Clydesdale Bank are shortly to 'go live' and the ten-member Matrix building society network is being integrated within LINK. In addition, the LINK switch is connected to the international PLUS SYSTEM network, based in Denver, Colorado, which serves 26 000 ATMs world-wide.

Transaction volumes on the switch, which handles the reciprocal transactions of the members' customers, have risen tenfold from 300 000 in February 1987, when the initial network went live, to more than three million per month at present.

Under the new facilities management contract, which has already come into effect, BT is running the LINK central switch computer and associated telecommunications circuits. BT has again selected CONNEX† electronics funds transfer software, supplied in the UK by Scicon, running on Tandem processors, in an enhancement of the present LINK operation, which is currently managed by BT.

The contract will enable LINK to continue to provide a high-quality service to its members' 11 million cardholders.

† CONNEX is a trademark of Deluxe Data Systems Inc.

New Exchange Paves Way for ISDN to Europe Next Year

A new electronic exchange has been ordered by BT which will open the way next year for BT to connect its own growing integrated services digital network (ISDN) in the UK to similar networks being established in West Germany, France, Italy and other European countries. It can be used to provide other ISDN links.

These new links will be made through a Northern Telecom DMS 300 Supernode digital integrated services switching unit (ISSU) being supplied by STC's Digital Switching Division. BT's first international gateway using STC/Northern Telecom technology, the ISSU is due to be ready for service during the first half of 1990.

The new ISSU will maintain British Telecom International's (BTI's) position as one of the front runners in the race to provide international integrated digital services, and will enable it to stay ahead of growing customer demand. BTI's plans for Europe are a swift and positive response from BT to the memorandum of understanding for the provision of pan-European ISDN services announced recently by the CEPT.

The new services to Europe provided through the DMS 300 gateway will enable users to set up digital desk-to-desk communications paths of 64 kbit/s. This will allow BT, in collaboration with administrations in Europe, to provide customers with new services which can exploit this advanced capability.

Book Reviews

Electronic Devices and Components. Second Edition

J. Seymour.
Longman Scientific and Technical. 575 pp. 353 ills. £14·95.
ISBN 0–582–01493–X

The author is the Principal Lecturer in the School of Computing and Information Technology at Thames Polytechnic. His book is essentially a course or textbook for students in higher education.

In 11 chapters, the book covers most of the common active components used in modern electronics. In addition to semiconductors, there are chapters on vacuum and magnetic devices plus dielectric materials. Seven of the chapters cover the background physics, materials, technology and characteristics of semiconductor components, including integrated circuits and gallium arsenide devices for use at high frequencies.

With such wide coverage, there is insufficient depth for a specialist in any topic. However, there is sufficient physics to instruct or remind device users of the fundamental theory of each device. This starts with the physics of atoms and progresses quite logically through semiconductor band theory to device equations and characteristics. For the enthusiast, there is even greater coverage in three appendices, briefly covering: wave mechanics, electron densities in semiconductors and SPICE circuit simulation.

This treatment of devices will be a useful reminder that all components, even LSI digital ICs, are based on analogue parameters and characteristics. An understanding of the operation of basic components is often required, particularly when mixing technologies in a system.

The organisation of text within each chapter is exemplary and is easily read throughout or dipped into for reference. The titled sub-topics provide the concepts and basic theory and are equally good as a part of the chapter or for instant reference. At the end of each chapter is a very brief summary of points to remember and a set of problems (no answers). These both serve to remind the reader of the underlying concepts and then test whether the reader has understood and can apply them. Also, there are a few worked examples amongst the text.

The greatest strengths of this book, amongst many with a similar subject range, are the wide coverage, modest price, excellent layout and clear descriptions. It will appeal primarily to students in electronics and related subjects but has much to recommend it to practising engineers who use electronic devices and who wish to learn more about them.

P. J. T. MELLOR

Mathematics for Communication Engineers

H. B. Wood.
Ellis Horwood Ltd. 437 pp. 188 ills. £44·95.
ISBN 0–7458–0572–8

This is very much a book written by an engineer for engineers, for whom mathematics is seen as a means to an end rather than an end in itself. It is aimed at communication and electronic engineers, and undergraduates in such subjects. Relatively little is assumed in the way of mathematical knowledge, although familiarity with electrical engineering concepts is taken for granted. The exposition proceeds very simply from introductory ideas, through to practical examples. For instance, the first chapter, 'Complex Numbers', introduces the concept of complex numbers by way of the rotational j operator, and goes on to show how these can be used to analyse the behaviour of electrical circuits, with worked examples.

The remaining four chapters are entitled 'Fourier Analysis', 'The Laplace Transform', 'Vector Analysis' and 'Probability Theory', and in each case the technique is applied to solving actual engineering problems. For example, the treatment of vector analysis is geared to Maxwell's equations and used to look at antenna gain.

A quarter of the book is devoted to some eight appendices, which cover topics ranging from partial fractions to complex integration and Bessel functions. Scattered throughout the book are a number of computer programs written in BASIC, which describe how to implement certain tasks, such as finding the area under a curve (one of the appendices), or calculating the error function. The aim of such programs is to enable results to be obtained when the mathematical expression is intractable, and reflects the practical bias of the book. An index to these programs would have been useful.

The last quarter of the book is devoted to exercises, followed by their solution, which provides a useful way of consolidating knowledge.

A criticism of the book is the absence of references, thus the reader is given no guidance in where to look for deeper results on a particular topic. Also, little indication is given of the limitations of the numerical techniques presented, and error bounds are not given.

Notwithstanding these remarks, the book does serve as a good self-contained introduction to the mathematics that communications engineers will need. Its strength is the simple step-by-step approach it takes.

P. B. KEY

Developing Expert Systems

Georgios I. Doukidis, and Edgar A. Whitley.
Chartwell-Bratt Ltd. 232 pp. 17 ills. £6·95.
ISBN 0–86238–196–7

The book gives an elementary introduction to expert system technology. The approach is rather pragmatic. Nevertheless, a fairly broad exposition of expert system development topics is given which necessarily sacrifices a certain degree of depth. Integration of expert system technology with the main data processing activities in business organisations is seen as a natural progression towards automating the capture and incorporation of more complex decision making processes.

A range of technical issues in expert system development, such as knowledge representation, inference techniques, knowledge acquisition (KA), artificial intelligence tools, etc., are discussed. A relatively detailed treatment of KA techniques is given and KA is viewed as the first and major phase of expert system development.

The structure of the book is rather fragmented and is not totally coherent. A good part of the book is allocated to discussing the unnecessary details of knowledge and rule structures of PESYS, an expert system shell developed by the authors.

Overall, the treatment of the subject matter is rather 'academic' and as such it is a good and inexpensive introduction to expert system technology for university undergraduates. In particular, despite the broad technical coverage, the reader will not find any analysis on how to initiate and manage real large-scale expert system projects.

M. AZMOODEH

Product News

Combined BTeX ACD Telephone System

BT has announced the launch of its BTeX ACD, a fully-featured combined digital PABX and automatic call distribution (ACD) system based on its existing successful BTeX product range.

The new BTeX ACD is a highly flexible system which facilitates both the operation and management of all telephone traffic. The wide range of BTeX system hardware addresses the majority of ACD customer requirements and can be tailored to meet individual customer needs.

The ACD software enables incoming calls from clients to be held in a queue, with an automatic queue overflow when call volumes are particularly high. Calls are answered in strict rotation and are presented automatically to the agent's headset—the longest waiting call to the first available free agent. This ensures maximum efficiency in both call response and call processing time.

Furthermore, the BTeX system offers two immediate-response alternatives—'music-on-hold' or recorded announcement facilities—to reassure callers that they will shortly be attended to.

The BTeX ACD software package also includes an integral standard management package which provides details of call volumes and management statistics to assist in the planning of staffing levels and in anticipating and catering for varying demands on the telephone resources available.

The new BTeX ACD system uses a BTeX featurephone with headset operation. A supervisor featurephone can display various agent and queue status information. In addition, a VDU is provided to facilitate overall monitoring and changes to the ACD operation.

In addition, an optional management information system, giving more comprehensive and complex management reports and statistical breakdowns, may also be accessed via new, very-powerful and extremely-flexible ACD software. An external processor stores historical data from the BTeX system in order to output management reports as required by the more sophisticated ACD user.

The BTeX ACD—British Telecom's new combined digital PABX and automatic call distribution system

The BTeX ACD will enable companies which handle a high number of incoming calls to improve customer service and increase efficiency as well as offering the opportunity to reduce operating expenses.

British Telecom Launches the New Marquis II

BT has announced the launch of Marquis II, an enhanced version of its successful Marquis key telephone system.

Marquis II has a capacity of six exchange lines and eight extensions, which can be increased to 16 extensions with the simple addition of an eight-port extension card. It is an extremely flexible system incorporating a number of new software features and enhancements that make it an attractive new offering for the existing Marquis customer base.

The sophisticated features provided by Marquis II, many of which are normally only found on larger switching systems, include 30 customer-programmable abbreviated dial codes, 'do not disturb' and night service.

Single-button extension calling and LEDs, providing an at-a-glance awareness of extension status, further enhance the smooth and efficient operation of the system. Universal line access and call pick-up from any extension also offers customers greater operational flexibility by avoiding the necessity for a dedicated operator.

In addition, a wide range of easy-to-operate features are available to assist in the smooth operation of all telephone traffic. These include call hold and call enquiry, ring back on hold, abbreviated dialling, last number redial, mute button, a paging facility and enhanced telephone security through simple call barring and lock codes.

The new terminal's upgraded loudspeaking facility has been achieved by using new circuitry. Busy executives can now enjoy clear hands-free conversation even several feet away from their desks. The added benefit of this facility is that it allows several people to have a group discussion via the same telephone.

The Marquis II is customer-programmable and can be tailored to meet specific requirements on installation and as the business develops and needs change.

There are three Marquis II featurephones available. In ascending order of sophistication, they are the *Standard*, the *Hands Free* and the top-of-the range *Hands Free Plus*. The Marquis II Standard and Hands Free featurephones are both compatible with the existing Marquis system.

New Pentara+Plus Telephone System

BT has announced the launch of the Pentara+Plus, a new enhanced version of the Pentara 100E telephone system.

The new Pentara system, using an enlarged processor and incorporating a new version of software, offers a number of additional features and facilities and is ideally suited to meet the needs of medium-to-large-sized businesses. Designed by BT and manufactured in the UK, the system can function as a compact stand-alone unit, or may be 'piggy-backed' on a larger central PABX.

Pentara+Plus offers nominally up to 16 exchange lines and 76 extensions. It is a highly flexible telephone system which may be easily expanded as a customer's business requirements change. This also allows existing Pentara and Herald users to upgrade to a new system with the minimal financial outlay or disruption.

Simple to use and easily programmed, the Pentara system is available with a sophisticated range of systemphones enabling users to take full advantage of all its capabilities as well as catering for the specific needs of each extension user.

The system offers a wide range of features designed to maximise business efficiency including call hold; call transfer and divert facilities; conference call; hands-free dialling and speech; automatic redial for engaged numbers; 3-digit access to up to 100 frequently-used centrally-stored numbers; and a group call pick-up facility.

In addition, an enhanced alternative 'night service' is available which allows an operator to select at any time, by using a preprogrammed key, an alternative answering point for incoming calls, while the normal operator or answering position is unmanned.

A new speech synthesis facility allows an extension number allocated to an extension to be identified or checked by invoking a 3-digit code. Extension users will also be able to move terminals from one socket to another with all the numbers and programmed facilities associated with that terminal transferred at the same time.

Also offered are a number of new facilities accessed via optional hardware, designed to enhance and improve the management of all telephone traffic. These include account codes, call metering using meter pulse detection, enabling effective management of all calls, and sophisticated call barring facilities.

European Telecommunications Standards Institute

ETSI

Technical Assembly, July 1989, Nice

At its Technical Assembly held in Nice on 3 and 4 July, the European Telecommunications Standards Institute (ETSI), agreed a key component for the new integrated services digital network (ISDN) which is expected to be unrolled across Europe within about two and a half years.

The ISDN, which would support all telecommunications services, is a major priority to break down trade, technical and political barriers between the separate countries of Europe. Without this standardisation, the full potential of communication and data transmission across Europe will not be realised. The key component is the digital telephone which will sit in the European offices and homes of the 1990s.

In spite of intensive efforts, the experts across Europe had hit an impasse. They could not agree on three crucial matters. The Technical Assembly has broken through this impasse and unanimously agreed on the complete text of this component.

This was a crucial test for the effectiveness of ETSI to resolve differences of opinion. For European industry, it now offers the prospect for the first time of a European-wide market for tomorrow's telephone handsets.

Europeans travelling in the USA often remark on how far Europe is falling behind North America in telephone services provided on board air flights. A new project team, approved by ETSI's Technical Assembly, signals Europe's determination to catch up. The new project team experts will be based at ETSI's headquarters at Sophia-Antipolis near Nice in the South of France and will feed technical proposals to the key standardising group, RES 5.

The European Communities fund a large research and development programme in telecommunications called *RACE*, as a result of which many new products and services are expected to emerge in the 1990s.

Over the last 12 months, officials from the European Community and ETSI have been grappling with the problem of new standardisation issues which can be channelled from RACE into ETSI at the right time. If the issue arrives too late, industrial companies will already have committed significant resources and made European disputes inevitable. Europe could also miss the boat as far as international standardisation is concerned.

The ETSI Technical Assembly approved the principles of this important relationship. The decision is fully in line with the wish of the European Community to see a much closer relationship between research and development and standardisation.

Without this agreement, Europe would have reduced significantly the prospects of maximising its return on the 550 million ECU being spent on this important EC research and development programme.

ETSI has shaken off the last of the vestiges of CEPT (the European Conference of Posts and Telecommunications Administration). When ETSI was set up just over a year ago, it inherited a work programme from CEPT which represented the interests of Europe's PTTs (posts and telecommunications administrations). In a remarkable feat of multi-national management, it has maintained the full flow of the work programme and completely overhauled it at the same time. This overhaul was necessary to reflect fully the needs of users and industry, as well as the PTTs. The extent to which ETSI has kept up the pressure on the existing work items can be measured by the 25 draft standards now emerging.

The adoption of ETSI's first multiannual programme by the Technical Assembly also clearly sets out European developments for those who are following their progress throughout the rest of the world.

Notes and Comments

BT NEWS MISCELLANY

FASTER repairs, quicker installation of new residential and business telephone lines and equipment, improved directory enquiries, more working public payphones, and fewer call failures—are improvements confirmed in BT's Quality of Service Report covering the period between September 1988 and March this year. Compared with September last year (in brackets), the new figures show:

- Faults cleared within one working day, now 79·6% (64·3%).
- Faults cleared within two working days, now 94·6% (91·6%).
- Local calls failed because of defective equipment or congestion, 1·4% (1·7%).
- National calls failed because of defective equipment or congestion, 2·4% (3·5%).
- Business orders completed in six days now 61·8% (55·1%).
- Residential orders completed in eight days, now 69·4% (56·3%).
- Directory enquiry calls answered in 15 seconds, 85·1% (81·3%).
- Public payphones working at any one time, 96·5% (93·5%).

For the first time, the report included particular indicators of performance for London customers. These show:

- £700M invested in the London telephone networks and exchange equipment over the past year.
- More than 97% of faults cleared within two days for all customers—business and residential.
- More than 150 additional operators recruited to handle the demand for directory enquiry assistance and new centres opened in Yeovil, Torquay and Darlington to help deal with the increased volumes.
- 70% of private circuit orders completed within the agreed date.
- 75% of private circuit faults repaired within 5 hours.

A NEW information service for the process-control and instrumentation industry, linking manufacturers, distributors, instrument engineers and buyers to an on-line interactive network, is to be marketed by Dialcom UK and INDEX-i Ltd.

Dialcom UK is BT's supplier of electronic information, transaction and messaging services; INDEX-i is an Aberdeen-based private company set up by a group of professional engineers early in 1986 to develop databases for process engineering and other markets.

The new service—PASSWORD Instrumentation—is part of Dialcom's recently announced repertoire of database and transaction services for the engineering industry. It allows customers to specify multiple parameters on their terminals, select suitable instruments from the resulting data display and then request quotations or place orders direct from their keyboards using Telecom Gold, Dialcom UK's electronic mail service.

All types of instrument used in the process and manufacturing industries are covered, ranging from sensors and transmitters to chemical analysers and self-tuning controllers. The level of technical detail provided is a vital part of the service, and can be as much as eight pages of data along with annotated graphical drawings.

BT, together with six other international companies, has joined with the Ministry of Posts and Telecommunications (MPT) of the Soviet Union in a project to study the feasibility of constructing a trans-Soviet optical-fibre telecommunications link, connecting Europe and Japan. The system could also access South-East Asia and Australia via other cable systems.

Joining BT in the agreement with the MPT of the Soviet Union are Great Northern Telegraph Co. (GN) of Denmark, Kokusai Denshin Denwa Co. Ltd. (KDD) of Japan, Overseas Telecommunications Commission (OTC) of Australia, Societa Finanziaria Telefonica PA (STET) of Italy, Telecom Denmark, and US West International of the United States.

IN RECOGNITION of the strategic importance of the USA in BT's plans, the company has announced the appointment of Mr. John Carrington as President, BT Inc. He was previously Director of BT Mobile Communications, and while he will have executive responsibility for all BT's operations in North America, his new appointment reflects the growing role that mobile communications is playing in the development of telecommunications in the United States. Mr. Carrington's role will be to develop and co-ordinate BT's growing business interests in America, provide an increasingly effective service to BT's multi-national clients, and establish and enhance marketing outlets for the company's expanding range of products and services.

BT has announced the appointment of Stafford Taylor, formerly chief executive of Warrington-based MBS, as managing director of Cellnet, the cellular mobile radio network run jointly with Securicor. He reports to Dr. Sydney O'Hara, joint managing director of operations of BT's Communications Systems Division (CSD).

ENGINEERING COUNCIL—AIMS AND OBJECTIVES

The Engineering Council has taken a new look at its aims and objectives in its Annual Report for 1988, published in May. Its six main aims now are to develop and promote, for the public good and the well-being of the national economy, all aspects of UK engineering by

- Increasing awareness of the essential and beneficial part engineering plays in all aspects of modern life.
- Advancing engineering knowledge through education and training.
- Spreading best engineering practices to improve the efficiency and competitiveness of UK businesses.
- Ensuring, by direct action and encouragement, a sufficient supply of registered Chartered and Incorporated Engineers and Engineering Technicians.
- Stimulating and leading discussions aimed at reaching decisions on the standards of education, training, re-training and experience necessary to meet defined engineering competence criteria.
- Co-operating with, and where appropriate co-ordinating the work of, any organisations, groups or individuals whose activities have an engineering dimension.

The Council seeks to achieve these aims by:

- Advising, and when necessary lobbying, the Government, in conjunction with public and private sector representatives,

on the national level policies, actions and resources essential to ensure the proper supply and quality of qualified engineers and technicians.

- Promoting, maintaining and expanding the register of Chartered Engineers, Incorporated Engineers and Engineering Technicians as the recognised hallmark of achieved standards.
- Encouraging Chartered Engineers, Incorporated Engineers and Engineering Technicians to take part in the United Kingdom's affairs at a national level and to promote, specifically with employers, the recognition of their value and contribution.
- Generating strong and effective links between education and industry so that children, parents and teachers are aware of the benefits of a career in engineering to individuals and the country.
- Demonstrating the need to make best use of existing and new technology together with product design.
- Seeking to optimise the benefits of European integration through discussions with industry, learned societies, the professional institutions and Government.
- Utilising the Council's national network to the full in order to spread 'The Engineering Message'.
- Promoting, among employers and employees, the benefits of continuing education, training and re-training not only in the basic engineering disciplines but, increasingly, in managerial and linguistic skills.
- Highlighting engineering careers for women and seeking means to retain and maximise their skills and experience beyond any career break, through the Women Into Science and Engineering (WISE) campaign.
- Encouraging fresh approaches to educational courses and training programmes with particular emphasis on interdisciplinary aspects.
- Concentrating professional engineering resources and so strengthening their influence, by developing co-operation between institutions.
- Encouraging timely and advantageous institutional mergers.
- Stressing the need for a proper balance between efficiency, public safety and the needs of the environment when carrying out engineering activities.

ALTERNATIVE ROUTE TO THE ACADEMIC STANDARD FOR CHARTERED ENGINEER

An alternative route to achieving Chartered Engineer status for people who did not study for a degree on leaving school is outlined in a new leaflet issued by The Engineering Council. It describes the Council's own world-wide degree-level examination which is aimed primarily at men and women already working in industry.

Many of them believe that the only way they can meet the academic standard for Chartered Engineer is by obtaining an accredited UK degree in engineering. This is not so: an engineer who has obtained a good Higher National Diploma or Certificate, or a non-accredited degree, or even a lesser qualification would do well to consider The Engineering Council Examination.

Programmes of study for The Engineering Council Examination are offered at polytechnics and colleges not only on a full-time but also on a part-time day and evening basis. The examination is held in May each year at recognised and specially arranged centres in the UK and throughout the world.

The examination is in two progressive parts. Part 1 consists of six subjects, four compulsory and two optional selected from a list. The normal entry requirement is two GCE A-level passes but not necessarily in science-based subjects, although these are preferred. Alternative entry qualifications are Ordinary National Diplomas and Certificates recognised by the Council for this purpose. The standard of the Part 1 Examination is that reached by an undergraduate about one third of the way through a British engineering degree.

The Part 2 Examination is divided into three sections: Part 2(A) consists of five technical subjects selected from a list of more than 40 covering the different disciplines of engineering; Part 2(B) is a single subject 'The Engineer in Society', which is compulsory for all candidates; Part 2(C) is the submission of a report on an engineering project that has been undertaken.

Entry to Part 2 is by passing Part 1 or by gaining a qualification recognised by the Council as giving exemption from Part 1. The Council will accept a Higher National Diploma or Certificate qualification at a good standard for exemption purposes. Those with non-accredited degrees could be given exemption from some of the five Part 2(A) subjects and possibly from Part 2(B) and Part 2(C). The standard of the Part 2 Examination is that of an accredited British engineering degree. Upon successful completion of the Examination, a certificate of success is awarded.

The Council also makes available for purchase at nominal cost: rules, syllabuses, past papers, reading lists and examiners' reports.

Success in the Examination together with the right training and experience and Institution membership leads to the qualification Chartered Engineer and the use of the designatory letters C.Eng. Application may then be made for the qualification European Engineer, EurIng.

Further details from: the Examinations Officer, The Engineering Council Examination, Savoy Hill House, Savoy Hill, London WC2R 0BU. Telephone: 01-379 7459.

1989-90 IEE FARADAY LECTURE

The 1989-90 IEE Faraday Lecture series—Electric Currency—will be presented by the Bank of Scotland. Banking in the late twentieth century has undergone a revolution, principally because of the emergence of information technology. The Lecture examines how money has become increasingly 'invisible' as a result of this development and provides practical demonstrations of electronic banking systems in operation. It will be informative aand entertaining and is designed to appeal to everyone.

The itinerary is as follows:

1989		
Glasgow	Scottish Exhibition Centre	21 September
Inverness	Eden Court Theatre	26 September
Aberdeen	Music Hall	28 September
Manchester	Free Trade Hall	4 October
Newcastle	City Hall	11 October
Liverpool	Empire Theatre	18 October
Cambridge	Corn Exchange	1 November
Harrogate	Conference Centre	9 November
Birmingham	Town Hall	14 November
Reading	Hexagon	23 November
Brighton	The Dome	29 November
Torquay	English Riviera Centre	12 December
1990		
Cardiff	St. David's Hall	16 January
Bristol	Colston Hall	24 January
London	Barbican Centre	30/31 January 1 February
Portsmouth	Guildhall	6 February
Leicester	De Montfort Hall	13 February
Sheffield	City Hall	28 February
Dundee	Caird Hall	7 March
Edinburgh	Usher Hall	13/14 March

Tickets are free and can be obtained by sending a stamped addressed envelope to Faraday Officer, IEE, Michael Faraday House, Six Hills Way, Stevenage, Hertfordshire SG1 2AY (Tel: 0438 313311), or by application to branches of the Bank of Scotland.

PUBLICATION OF CORRESPONDENCE

A regular correspondence column would make a lively and interesting feature in the *Journal*. Readers are therefore invited to write to the editors on any engineering, technical or other aspects of articles published in the *Journal*, or on related topics. Letters of sufficient interest will be published under 'Notes and Comments'. Letters intended for publication should be sent to the Managing Editor at the address given below.

CONTRIBUTIONS TO THE JOURNAL

Contributions of articles to *British Telecommunications Engineering* are always welcome. Anyone who feels that he or she could contribute an article (either short or long) of technical, managerial or general interest to engineers in British Telecom and the Post Office is invited to contact the Managing Editor at the address given below. The editors will always be pleased to give advice and try to arrange for help with the preparation of an article if needed.

Educational Papers

The Editors would like to hear from anyone who feels that they could contribute further papers in the series of educational papers published in the *Supplement*. Intending authors should contact the Deputy Managing Editor, at the address given below. An honorarium will be offered for suitable papers.

Guidance for Authors

Some guidance notes are available to authors to help them prepare manuscripts of *Journal* articles in a way that will assist in the uniformity of presentation, simplify the work of the *Journal*'s editors, printers and illustrators, and help ensure that authors' wishes are easily interpreted. Any author preparing an article is invited to write to the Managing Editor, at the address given below, to obtain a copy.

All contributions to the *Journal* must be typed on one side only of each sheet of paper. As a guide, there are about 750 words to a page, allowing for illustrations, and the average length of an article is about six pages, although shorter articles are welcome. Contributions should preferably be illustrated with photographs, diagrams or sketches. Each circuit diagram or sketch should be drawn on a separate sheet of paper; neat sketches are all that is required. Photographs should be clear and sharply focused. Prints should preferably be glossy and should be unmounted, any notes or captions being written on a separate sheet of paper. Good colour slides can be accepted for black-and-white reproduction. Negatives are not required.

It is important that approval for publication is given at organisational level 5, and authors should seek approval, through supervising officers if appropriate, before submitting manuscripts.

JOURNAL DISTRIBUTION—NOTIFICATION OF CHANGES OF ADDRESS

IBTE Members and *Journal* subscribers who change their home address should ensure that they notify the *Journal* office on the address-label slip provided with every copy of the *Journal*.

All enquires related to distribution of the *Journal* should be directed to The Administration Manager at the address given below.

BTE JOURNAL/IBTE ADMINISTRATION OFFICE

All correspondence and enquires relating to editorial matters ('letters to the editor', submissions of articles and educational papers, requests for authors' notes etc.) and distribution of the *Journal* should be sent to the Managing Editor, Deputy Managing Editor, or Administration Manager, as appropriate, at the following address: *BTE Journal*/IBTE Administration Office, 3rd Floor, 84–89 Wood Street, London EC2V 7HL. (Telephone: 01–356 8050; Fax: 01–356 8051; Gold Mailbox: 73:TAI009.)

Forthcoming Conferences

Further details can be obtained from the conferences department of the organising body.

Institution of Electrical Engineers, Savoy Place, London WC2R 0BL. Telephone: 01–240 1871.

Software Engineering for Real Time Systems. 18–20 September 1989. Royal Agricultural College, Cirencester.

Computers and Safety. 8–10 November 1989. St. David's Hall, Cardiff.

Land Mobile Radio. 11–14 December 1989. Warwick.

UK IT 1990. 19–22 March 1990. University of Southampton.

Automated Test and Diagnosis. 9–12 April 1990. Bournemouth International Centre.

Factory 2001—Integrating Information and Material Flow. 9–12 July 1990. Churchill College, Cambridge.

Power Electronics and Variable Speed Drives. 17–19 July 1990. IEE, London. *Call for Papers*: Synopses by 1 September 1989.

Electromagnetic Compatibility. 28–31 August 1990. University of York. *Call for Papers*: Synopses by 29 September 1989.

THE INSTITUTION OF BRITISH TELECOMMUNICATIONS ENGINEERS

(Founded as the Institution of Post Office Electrical Engineers in 1906)

MEMBERSHIP OF THE FEDERATION OF THE TELECOMMUNICATIONS ENGINEERS OF THE EUROPEAN COMMUNITY

FITCE is an organisation of national associations with similar objectives to IBTE and draws its members from the public telecommunications administrations of Belgium, Denmark, Eire, France, Greece, Italy, Luxemburg, the Netherlands, Portugal, Spain, the United Kingdom and West Germany. FITCE sponsors multi-national study groups (Commissions) to enquire into and report on problems of general interest, and each year one of the member countries hosts a General Assembly/Congress at which a given technical theme is discussed.

IBTE is the sole representative body for the United Kingdom membership, having been accepted into the Federation in 1981. An IBTE Member, on joining FITCE, will become a Member of the FITCE Group of IBTE. FITCE Group activities are subject to the Institution's rules, but only the Group Members have voting rights on any rules which are exclusively concerned with FITCE Group affairs. A FITCE Group Member will be eligible for selection to serve on FITCE Commissions or to become an official delegate to (or attend unoffficially at own expense) General Assemblies/Congresses in accordance with FITCE Rules.

The Membership of FITCE is available to Members and Affiliated Members of IBTE who hold a University Science Degree and/or are Corporate Members of the Chartered Engineering Institutions and/or are Chartered Engineers.

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APPLICATION FOR MEMBERSHIP OF THE FITCE GROUP OF IBTE

Assistant Secretary, IBTE/FITCE Group
BTUK/NPW3.2.5, 2C75, The Angel Centre, 403 St John's Street, London EC1V 4PL

I wish to become a member of FITCE through the FITCE Group of IBTE and enclose a cheque for £5·00, made payable to IBTE, in payment of my subscription to 31 March 19____. My qualifications are as follows:

Degree ______________ University ______________________________ Year Awarded ____*

I am a Corporate Member of ____*

I am/am not* a Chartered Engineer (*Delete as appropriate*)

Date __________ Signature ______________________

NAME ______________________________ DUTY CODE ______________________

ADDRESS ______________________________ TEL: ______________________

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______________________________ POST CODE ____________

(BLOCK CAPITALS PLEASE)

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Your application for membership of the FITCE Group has been accepted. Your name and address will be forwarded to the FITCE Secretariat. Please advise of any change of address in writing.

Date ______________ Signed ______________________________Asst. Sec, IBTE/FITCE

THE INSTITUTION OF BRITISH TELECOMMUNICATIONS ENGINEERS

(Founded as the Institution of Post Office Electrical Engineers in 1906)

APPLICATION FOR FULL MEMBERSHIP

The object of the Institution of British Telecommunications Engineers is to advance the electrical and telecommunications sciences and their application, and facilitate the exchange of information on these and allied subjects.

ELIGIBILITY There are two classes of Corporate Membership (full definitions are given in Rules 5 and 6):

Member British Telecom (BT) staff in the Management and Professional Structure (M & PS), and senior management grades, who are or have been directly involved in the engineering, or scientific or technical work of BT, and equivalent Post Office (PO) staff.

Affiliated Member BT staff in the M & PS of Band A and above whose work is associated with that of Members, and equivalent PO staff.

Other engineering staff in BT and the PO may be eligible to join the Associate Section. Further details of the Associate Section can be obtained from local contact points (see p. 280 of the January 1989 issue of the *Journal*.)

MEETINGS keep Members informed on technical and related aspects of the work of BT and the PO and offer the opportunity for discussion. Details are given in the Centre programme. Members are entitled to claim official travel expenses from their headquarters to the meetings. Copies of papers read at the meetings are published locally and in selected instances nationally.

JOURNAL Each Member is supplied with a free copy of the quarterly *British Telecommunications Engineering*, a technical publication which is highly regarded worldwide by postal and telecommunications engineers. The *Journal* is sent to Members' home addresses.

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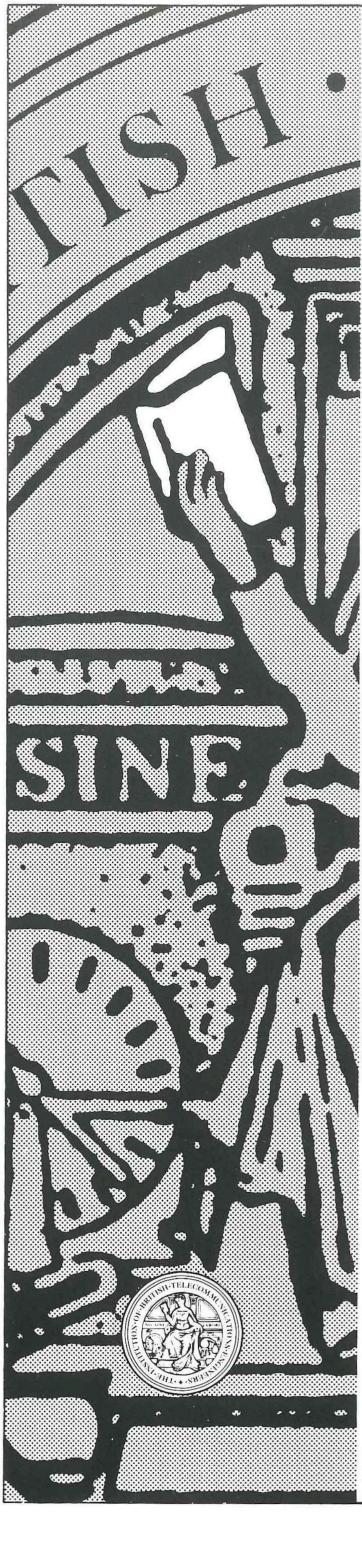

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